Framework Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area:

Volume II

Public Review Draft

December 16, 2005

Prepared for the Montana Department of Environmental Quality

Prepared by the U.S. Environmental Protection Agency, Montana Operations Office
With Technical Support from Tetra Tech, Inc. and PBS&J, Inc.

Project Manager: Ron Steg

CONTENTS

APPENDICES

Tables

Figures

Acronyms

303(d)	State of Montana's list of waters not meeting water quality standards
ARM	Administrative Rules of Montana
As	Arsenic
BLM	Bureau of Land Management
BMP	Best Management Practice
CFS	Cubic feet per second
Cd	Cadmium
Cu	Copper
CWA	Clean Water Act
DO	Dissolved oxygen
GIS	Geographic information system
GWLF	Generalized Watershed Loading Function model
Hg	Mercury
LSPC	Loading Simulation Program in C
MBER	Montana Board of Environmental Review
MDEQ	Montana Department of Environmental Quality
MFWP	Montana Fish, Wildlife, and Parks
MG/L	Milligrams per Liter
MG/M^2	Milligrams per square meter
MM	Millimeters
MRLC	Multi-Resolution Land Characterization
NPDES	National Pollutant Discharge Elimination System
Pb	Lead
SAP	Sampling and Analysis Plan
SSTEMP	Stream Segment Temperature Model Version 2.0
STATSGO	State Soil Geographic Database
TMDL	Total maximum daily load
TN	Total nitrogen
TP	Total phosphorus
TPA	TMDL planning area
TR	Total Recoverable
TSI	Trophic state index
TSS	Total suspended solids
USDI	United States Department of Interior
USEPA	United State Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
Volume I	Water Quality Restoration Plan and Total Maximum Daily Loads for the Lake Helena Watershed Planning Area (EPA, 2004)
WWTP	Wastewater treatment plant
Zn	Zinc

1.0 INTRODUCTION

In simple terms, a total maximum daily load (TMDL) is a plan to attain and maintain water quality standards in waters that are not currently meeting them. The waters not currently meeting water quality standards in the Lake Helena Watershed have been identified and described in Volume I of the *Water Quality Restoration Plan and Total Maximum Daily Loads for the Lake Helena Watershed Planning Area* (EPA, 2004) (incorporated herein by reference and hereafter referred to as "Volume I").

This document presents a plan to attain and maintain water quality standards in all of those waters considered impaired in Volume I. This document (i.e., Volume II) has been written/structured to be read and reviewed by both a non-technical audience as well as by those who may be interested in the technical details and regulatory context. The main body of Volume II includes: a summary of the approach and methods, a description of the water quality problems, a presentation of water quality goals, a summary of the sources of the water quality problems, and a conceptual plan for addressing the water quality problems. The main body of Volume II is intended to provide an overview at the watershed scale.

The required TMDL elements for each of the water body/pollutant combinations considered impaired in Volume I are presented in a separate appendix to facilitate easy review for regulators, watershed stakeholders that may be affected by them, and those interested in site-specific water quality restoration recommendations (Appendix A). Appendix A is presented at the scale of the individual water bodies and their associated sub-watersheds.

The technical details, including modeling and assessment methods, technical analyses, and results are also provided in appendices which have been referred to as appropriate in the main body of the document.

Document Contents

The main body of this document presents an overview at the watershed scale.

The TMDLs, and details at the sub-watershed scale, are presented in Appendix A.

Supporting technical analyses are presented in Appendix B through I.

2.0 APPROACH/METHODS

> **Approach**
>
> *This plan provides a framework for water quality restoration. A phased approach is proposed including an adaptive management strategy.*

The water quality issues in the Lake Helena Watershed are numerous, technically complex, and involve a large number of varied stakeholders ranging from federal and state resource agencies, to county and local governments, industry, the agricultural community, and watershed residents. While it is believed that the efforts summarized in Volumes I and II have advanced our understanding of water quality problems in the Lake Helena watershed considerably, given the available time and resources, it is not possible to prescribe a definitive plan of action to specifically address all of the issue in a detailed fashion at this time. Therefore, the intent of this plan is to provide a framework within which the most significant water quality problems are identified and prioritized, such that watershed stakeholders have the information they need to begin improving water quality conditions. It is also envisioned that the information presented in this plan, and some of the tools that have been prepared in support of developing this plan (e.g., water quality models), will provide a framework within which to make informed decisions in the future in consideration of water quality.

The overall approach for restoring water quality in the lakes and streams in the Lake Helena Watershed is three-phased; beginning with information gathering in Phase I, plan development in Phase II, and implementation in Phase III. A summary of the phased approach is presented in Table 2-1.

The goals of Phase I were to:

1. Develop an understanding of the physical, biological, and socioeconomic characteristics of the Lake Helena Watershed that may have had, or are having an influence on water quality;
2. Verify the water quality impairment status of all water bodies that have appeared on Montana's 303(d) lists and develop an understanding of the water quality impairments; and
3. Determine which water bodies are in need of Total Maximum Daily Loads.

The Lake Helena Volume I Report, completed in December 2004, summarized the results of Phase I. Volume I was made available to the public in February 2005 and public comment has helped to shape Phase II. A summary of the public comments received on Volume I and agency responses are presented in Appendix B. It should be noted that summaries of the conclusions reached in Volume I are provided in this document to facilitate reading this report. For detailed information on the determination of which water bodies are considered impaired and in need of a TMDL, the reader is referred to the Volume I document.

The purpose of Phase II was to identify the sources of the water quality problems described in Volume I, establish water quality goals or endpoints that will define attainment of water quality standards in the future, and to develop solutions for addressing each of the significant sources such that water quality standards can be attained and maintained in the future. The required TMDL elements (i.e., targets, total maximum daily loads, allocations, and margins of safety) have been developed in Phase II. Phase II/Volume II presents the plan to attain and maintain water quality standards.

The purpose of Phase III will be to conduct the necessary follow-up and/or supplemental studies to address uncertainties identified in Phase II and to implement the necessary actions to attain and maintain water quality standards. It is important to note that TMDLs are not self-implementing. Neither Section 303(d) of the Clean Water Act nor the Montana Water Quality Act creates any implementing authorities. TMDLs are only implemented through other programs and statutory mechanisms. Implementation tools vary and may include:

- National Pollutant Discharge Elimination System (NPDES) permits
- Other Federal, state, local laws & requirements (enforceable & voluntary)
- Individual, voluntary-based actions

A conceptual implementation strategy is presented in Section 4.0 of this document. However, actual implementation is beyond the scope of Volume II and will rely upon a combination of regulatory and voluntary means that will ideally be lead by watershed stakeholders.

Adaptive Management will be a key component of implementation. Given the complexity and scale of water quality issues in the Lake Helena Watershed, it will not be possible to answer every question and address each detail in this document. Conclusions reached and decisions made/documented in Volume II are based on the best information and data currently available. As new information becomes available in the future and/or conditions change, a strategy to evaluate the new information, react to it, and adjust components of the plan must be in place. Case-specific adaptive management strategies are presented throughout the document as they are needed. Adaptive management is also discussed in the conceptual implementation strategy (Section 4).

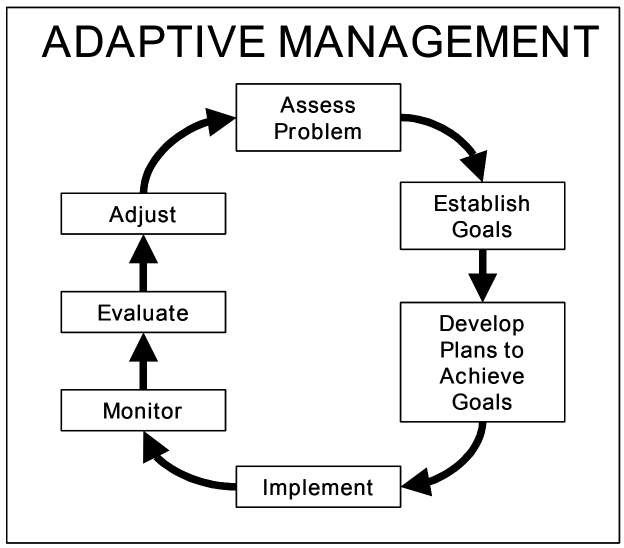


Table 2-1. Phased Approach.

2003 – 2004	2005	2006 →
Phase I – Information Gathering	**Phase II - Planning**	**Phase III – Proposed Implementation**
• Developing an understanding of the water quality problems. • Determined which water bodies needed TMDLs. • Solicited public comments. • Completed Volume I	• Revised some of the conclusions reached in Volume I based on public comments. • Identified the pollutant sources and relative importance of each. • Established water quality goals • Developed a pollutant load reduction plan to attain the water quality goals. • Completed Volume II	• Implement a coordinated effort at the watershed scale to reduce pollutant loading from both point and non-point sources. • Conduct follow-up and/or supplemental studies to address uncertainties identified in previous phases. • Revise, adjust, and manage adaptively as appropriate based on new information.

3.0 WATER QUALITY RESTORATION IN THE LAKE HELENA WATERSHED

To a large extent, current water quality in the Lake Helena Watershed is a result of man's activities within the watershed over the last 100 to 150 years. In the mid 1800s, mining activity increased due to the discovery of gold and other minerals in the mountains around the Helena valley. At the same time, the earliest miners and homesteaders began diverting water from Prickly Pear, Tenmile, and Silver Creeks to irrigate land for crops. Combined, hydrology and water quality experienced a period of rapid change due to the effects of irrigation, mining, and mine returns. Today, over 450 abandoned and operating mines currently exist and contribute to flow and water quality alterations in the watershed (MBMG, 2004).

In 1907, the hydrology of the Helena Valley was further altered with the completion of Hauser Dam and Lake Hauser on the Missouri River. As the reservoir filled, the low-lying wetlands of Prickly Pear and Silver Creeks flooded to form Lake Helena. In 1945, an earthen causeway and control mechanisms were constructed to separate Hauser Reservoir and Lake Helena, allowing the two to be regulated independently.

Between 1940 and 1970, intense logging occurred in the Lake Helena Watershed, primarily in the western portions of the watershed along the continental divide where the most marketable timber was located. During this period, a network of roads was built to harvest and transport the timber. Many of the impacts to streams observed today (particularly associated with stream channel morphology and sediment) are remnants from these activities (Personal Communications, Carl Davis, Helena National Forest Archaeologist, September 29, 2005).

Population growth and the associated infrastructure have also permanently altered the landscape and have played, and will continue to play, a role in defining water quality in the Lake Helena Watershed. Since the 1950's, population growth has averaged approximately 18 percent per decade.

In summary, the water quality conditions and water quality problems that exist today in the Lake Helena Watershed are a function of the activities that have occurred, and are occurring on the landscape. Volume I included an assessment and description of the known pollution problems based on the currently available data and separately addressed each of the water bodies that appeared on Montana's 1996 and 2004 303(d) lists. Based on the assessments presented in Volume I, the primary pollutants of concern include sediment, nutrients, metals, and temperature. The remainder of Section 3.0 presents a watershed scale overview, one pollutant at a time, including a summary of the sources of each pollutant, water quality goals, and proposed solutions for ultimately attaining and maintaining water quality standards. Water body-by-water body discussions and the associated TMDL elements are presented in Appendix A.

3.1 Sediment

The Problem:	Fish and aquatic life are not meeting their full potential in many streams due to excessive levels of sediment covering fish spawning and macroinvertebrate habitat, filling pools, and altering stream channel morphology.
Water Bodies of Concern:	Clancy Creek, Corbin Creek, Jennie's Fork, Lump Gulch, Middle Fork Warm Springs Creek, North Fork Warm Springs Creek, Warm Springs Creek, Prickly Pear Creek, Sevenmile Creek, Skelly Gulch, Spring Creek, and Tenmile Creek.
The Source:	Human-caused erosion primarily from dirt roads, agriculture, timber harvest, streambank erosion, abandoned mines, non-system roads, and urban areas.
In-Stream Sediment Goals:	Attain and maintain the applicable sediment water quality standards.
The Solution:	Reduce sediment loading from each of the significant human-caused sources.

Technical reports prepared in support of the sediment overview presented in this section of Volume II include:

- ***Appendix A*** *– Total Maximum Daily Loads (TMDL) Summary*
- ***Appendix B*** *– DEQ and EPA Response to Public Comments Received on the Volume I Document released on February 28, 2005*
- ***Appendix C*** *– GWLF/BATHTUB Modeling*
- ***Appendix D*** *– Supplemental Sediment Assessment*
- ***Appendix H*** *– Supplemental Monitoring and Assessment Strategy*

3.1.1 The Sediment Problem and Water Bodies of Concern

The surveyed streams in the Lake Helena Watershed that are not currently meeting Montana's narrative sediment standards are listed below and shown on Figure 3-1. Volume I provides details regarding the degree of impairment and how the impairments are manifested in each of the water bodies. In general, sediment is causing a loss of benthic productivity and fish habitat. Additionally, in some cases, human-caused sediment loading is resulting in high turbidity in streams that naturally flow relatively clear.

- Clancy Creek (MT41I006_120)
- Corbin Creek (MT41I006_090)
- Jennie's Fork (MT41I006_210)
- Lump Gulch (MT41I006_130)
- Middle Fork Warm Springs Creek (MT41I006_100)
- North Fork Warm Springs Creek (MT41I006_180)
- Prickly Pear Creek (MT41I006_060)
- Prickly Pear Creek (MT41I006_050)
- Prickly Pear Creek (MT41I006_040)
- Prickly Pear Creek (MT41I006_030)
- Prickly Pear Creek (MT41I006_020)
- Sevenmile Creek (MT41I006_160)
- Skelly Gulch (MT41I006_220)
- Spring Creek (MT41I006_080)
- Tenmile Creek (MT41I006_142)
- Tenmile Creek (MT41I006_143)
- Warm Springs Creek (MT41I006_110)

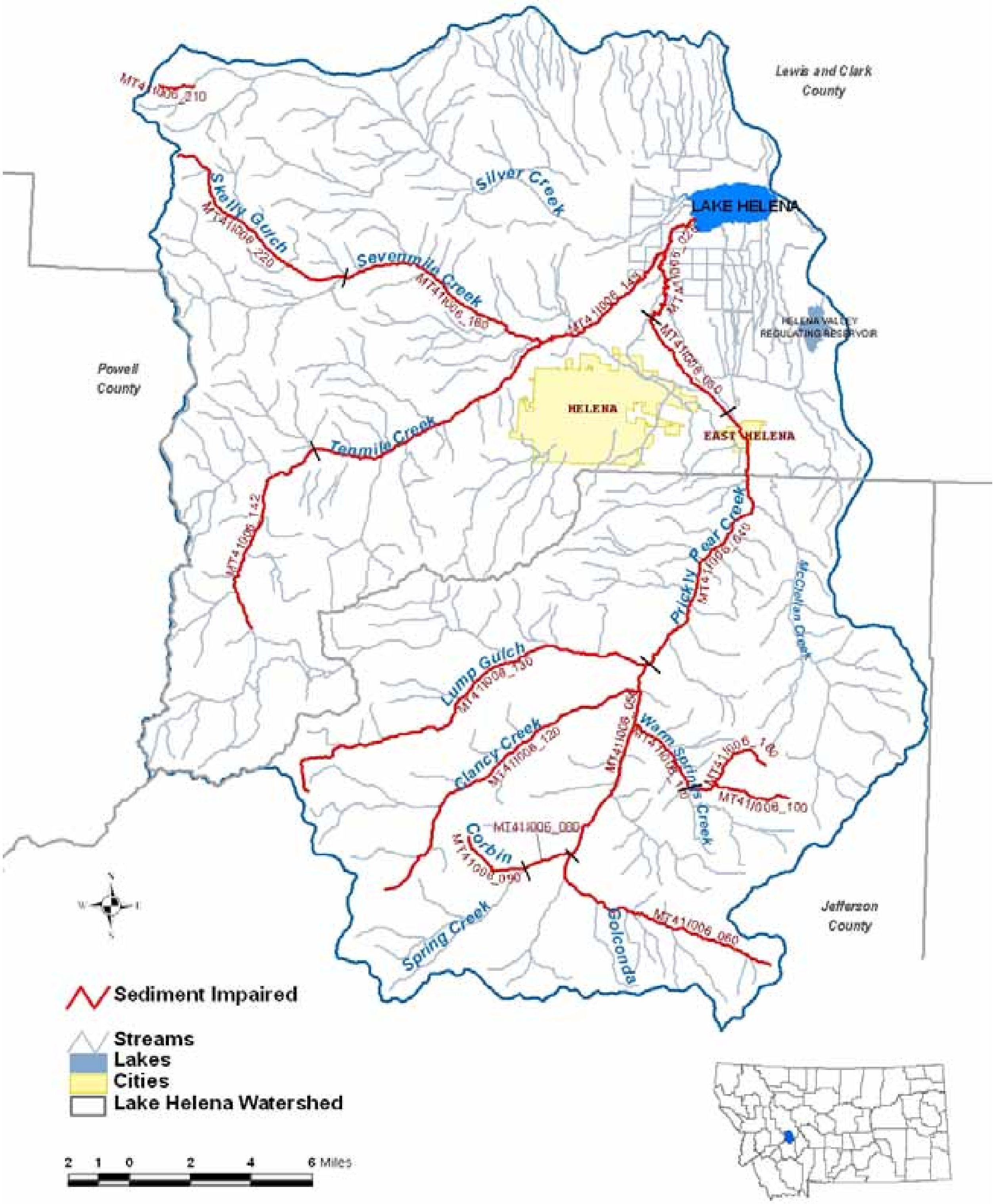


Figure 3-1. Streams in the Lake Helena watershed impaired by sediment.

3.1.2 Sources of Sediment in the Lake Helena Watershed

In general, excessive sediment loading from a variety of human-caused sources is the cause of the sediment impairment. Potential sources of sediment considered in this analysis included paved and unpaved roads, agriculture, forest harvest, stream bank erosion, storm water, mining, and a variety of natural sources (e.g., undisturbed forest, undisturbed grassland, etc.). The estimated loads from each of these sources for each of the impaired streams are presented in Appendix A. Source loads were estimated using the Generalized Watershed Loading Function model (GWLF) (see Appendix C) in combination with the use of remote sensing techniques, field surveys, streambank stability studies, and site-specific road analyses (see Appendix D).

When considering each of the above listed stream segments together, dirt roads, agriculture, timber harvest, streambank erosion, abandoned mines, non-system roads, and urban areas contribute 15, 10, 10, 7, 3, 1, and 1 percent of the total sediment load, respectively (Figure 3-2). On average, sediment loading is approximately 47 percent above the naturally occurring level.

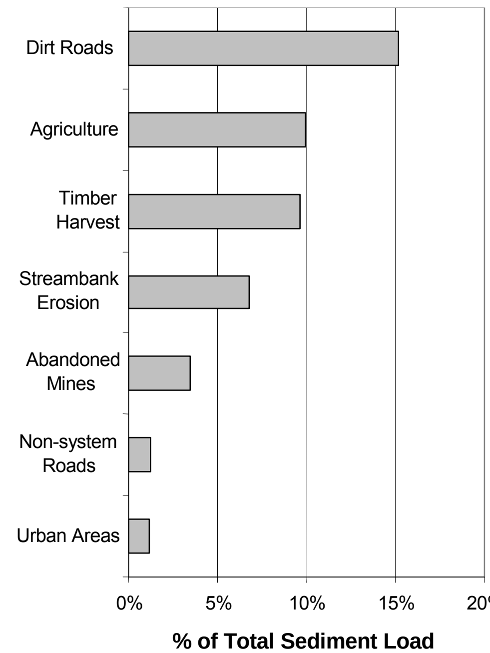


Figure 3-2. Average Sediment Loads in the Lake Helena Watershed.

The relative importance of individual source categories (e.g., dirt roads, agriculture, etc.) varies dramatically from stream to stream (see Appendix A). For example, agricultural sediment loading tends to increase in importance in the downstream reaches of the Lake Helena Watershed. In contrast, the relative importance of sediment loading from dirt roads, forest harvest and abandoned mining tends to increase towards the headwaters region of the watershed. Human-caused streambank erosion is common throughout the watershed.

3.1.3 In Stream Sediment Goals

The ultimate goal of this water quality restoration plan and associated TMDLs is to attain and maintain water quality standards. Montana's water quality standards for sediment are narrative and, therefore, must be interpreted to derive measurable water quality goals. A suite of measurable sediment indicators was developed and described in Volume I to facilitate interpretation of the narrative sediment standards. This suite of indicators was selected based on the best data and information available when Volume I was completed. Since that time, EPA and Montana DEQ have begun to develop a new suite of biological indicators that, when fully developed, may make the biological indicators presented in Volume I obsolete. Also, since Volume I was completed, MDEQ has begun to develop a new methodology for interpreting/translating the narrative sediment criteria (currently in conceptual draft form). When this methodology is completed, the sediment approach presented in Volume I may also be obsolete.

Since the success of this plan and associated TMDLs will be formally evaluated five years after it is approved (i.e., 2011 assuming TMDL approval in 2006), flexibility must be provided herein with the proposed suite of indicators selected to interpret the narrative sediment standards. The indicators presented in Table 3-1 are proposed as end-point water quality goals (i.e., targets) for sediment, in recognition of the fact that they may need to be changed in the future as new information becomes available and/or MDEQ implements a new methodology for interpreting the narrative sediment standards.

The suite of indicators used to evaluate compliance with Montana’s sediment standards in the future should be selected based on the best data and information available, and/or the current MDEQ methodology available, at that time.

Table 3-1. Proposed Sediment Water Quality Endpoints.

Water Quality Indicators	Rationale for Selection of this Indicator	Proposed Criteria
Percentage of subsurface fines < 6.4 mm size class, expressed as a reach average, in McNeil core samples collected in trout spawning gravel beds.	Substrate fine materials less than 6 mm are commonly used to describe potential success of fry emergence, and this size class includes the range typically generated by land management activities. There is an inverse relationship between the percentage of material < 6 mm and the emergence success of westslope cutthroat trout and bull trout (Weaver and Fraley, 1991). This indicator provides information regarding sediment supply (i.e., is there too much sediment) and an indirect linkage between sediment supply in a stream and potential impacts to the cold-water fishery.	The reach average value must be less than or equal to the average value for all Helena National Forest reference stream core samples.
Percentage of surface fines < 2.0 mm size class	Studies have shown that increased substrate fine materials less than 2 mm can adversely affect embryo development success by limiting the amount of oxygen needed for development (Meehan, 1991). As with the previous indicator, this indicator provides information regarding sediment supply (i.e., is there too much sediment) and an indirect linkage between sediment supply in a stream and potential impacts to the cold-water fishery. This indicator also provides an indirect linkage to potential impacts to macroinvertebrates.	≤ 20%
Channel width/depth ratio	The bankfull width to depth ratio is indicative of the ‘quasi-equilibrium’ relationship between stream discharge and load transport (Ritter et al. 1995). Increasing width to depth ratio is correlated to stream aggradation and bank erosion (Knighton, 1995 and Rowe et al., 2003).	Comparable to reference values.
Bank erosion hazard index (BEHI) score	The bank erosion hazard index is a composite metric of streambank characteristics (bank height, bankfull height, rooting depth, bank angle, surface protection, and bank materials/composition) (Rosgen, 1996). Measurements for each metric when combined produce an overall score of bank erosion potential. Low values indicate a low potential for bank erosion.	Comparable to reference values.
Median surface particle size (D_{50})	A clear trend of decreasing particle sizes in riffles is correlated with increasing hill slope disturbance. Moreover, there is a statistically significant difference in average and minimum D_{50} values when comparing reaches in undisturbed and less disturbed watersheds with reaches in moderately and highly disturbed watersheds (Knopp, 1993).	Comparable to reference values.
Proper Functioning Condition (PFC) riparian assessment	The PFC method is a qualitative method for “assessing the physical functioning of riparian-wetland areas” (Prichard, 1998). The hydrologic, riparian, and erosion/deposition processes of a stream reach are evaluated. Reaches that are in PFC typically have minimal riparian disturbance, stable streambanks, and the ability to withstand high discharge events.	“Proper Functioning Condition” or “Functional – at Risk” with an upward trend.
Macroinvertebrate IBI to be determined	A measure of macroinvertebrates will provide a direct measure of aquatic life health. It should be noted, however, that this indicator will not directly provide information regarding potential violations of Montana’s narrative sediment standards.	To be determined

3.1.4 The Solution

The hypothesis put forth in this plan is that the water quality standards (i.e., as measured by the indicators and approach presented in Section 3.1.3) will be met if all reasonable land, soil, and water conservation practices are employed for each of the significant sediment sources (e.g., dirt roads, agriculture, timber harvest, streambank erosion, abandoned mines, non system roads, and urban areas). Specific sediment load reduction goals have been proposed for each of these sediment sources (see Appendix A). It is assumed that the load reduction goals equate to the application of all reasonable land soil and water conservation practices.

The proposed load reduction goals and their rationale, for each sediment source, are presented in Table 3-2. Uncertainties are also acknowledged and discussed. Monitoring and adaptive management strategies to address these uncertainties are presented in Section 4.0. Sediment TMDLs are presented in Appendix A.

All Reasonable Land, Soil, and Water Conservation Practices

On average, sediment loads to the impaired streams in the Lake Helena Watershed must be reduced by approximately 47 percent to achieve "natural" sediment loading levels. However, Montana's water quality standards recognize that it may not be possible to achieve pre-human settlement, pristine water quality conditions. Montana's water quality standards define "naturally occurring" conditions as those where all designated beneficial uses are supported and all "reasonable, land, soil, and water conservation practices" are employed. In other words, there is some allowance for human activity so long as all designated beneficial uses are supported.

Table 3-2. Sediment Load Reduction Approach by Source Category.

Source Category	Pollutant Load Reduction Approach, Rationale, and Assumptions	Uncertainty
Current Timber Harvest	It is assumed that sediment loading from currently harvested areas will return to levels similar to undisturbed forest through natural recovery and application of BMPs. GWLF was used to estimate the load reductions associated with re-growth of vegetation in the harvested areas.	Because private harvest data were not available, the assumption was made that harvesting occurs at a continuous rate allowing for a 90-year harvest cycle (1/90 of private land is harvest each year). However, it is more likely that large cuts occur sporadically. Therefore, load reductions in any individual subwatershed could be over or under estimated.
Unpaved Roads	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
Non-system roads	Ideally all non-system roads should be closed and reclaimed. It is assumed that sediment loads from this source category will be eliminated.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
Urban Areas	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed (Schueler, 1997; Barnes and Gerde, 1993)	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
Anthropogenic Streambank Erosion	The goal for this source category is to reduce all human-caused stream bank erosion to levels expected in undisturbed or reference streams. Reference levels have been estimated based on Bank Erosion Hazard Index (BEHI) scores from reference streams in the Beaverhead-Deerlodge National Forest as follows: A channels = 21.06, B channels = 20.49, C channels = 20.32, and E channels = 18.77 (Bengeyfield, 1999). (See Appendix D)	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
Abandoned Mines	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79% (See Appendix D).	The range of observed sediment reduction from reclamation at five mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
Agriculture	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed resulting in a 60% sediment load reduction and alternative crop management practices will minimize the area of bare soil.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
Helena Valley Irrigation System	This is not currently a source of sediment to any of the subject streams. However, based on field studies conducted in 2005, the irrigation system appears to deliver a significant sediment load to Lake Helena in the spring. This source category should be considered and addressed as part of the phased efforts to address water quality issues in Lake Helena.	NA
Other Sources	A variety of other potential sediment sources have been considered in this analysis, but were not determined to be significant at the watershed scale. Where other sources, not discussed herein, are determined to be important at the subwatershed scale, they are discussed in Appendix A.	Uncertainties associated with proposed load reduction approaches for other sources that may be important at the subwatershed scale are addressed individually in Appendix A.
Natural Background	No load reductions are proposed from source categories considered natural (e.g., undisturbed forest lands, undisturbed grasslands, etc.).	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.

3.2 NUTRIENTS

The Problem:	Excessive nutrient loading is resulting in nuisance levels of algae and low dissolved oxygen in streams, thereby impairing the recreation, fish, and aquatic life beneficial uses. Available data also suggests that nutrients may be decreasing water clarity and increasing the incidence of algal blooms in Lake Helena. If population growth in the watershed continues at current rates and nutrient loading is not curbed, water quality is predicted to deteriorate further.
Water Bodies of Concern:	Prickly Pear Creek, Sevenmile Creek, Spring Creek, Tenmile Creek, Lake Helena.
The Source:	Nutrient loading from non-point and point sources.
Nutrient Goals:	The ultimate goal is to attain full beneficial use support relative to impairments that may be caused by nutrients. While sufficient information is available to determine that beneficial uses are impaired by nutrients, there is not sufficient data to select final nutrient threshold values for the lakes and streams in the Lake Helena Watershed at this time. As a result, interim nutrient goals are proposed in combination with an adaptive management strategy to revise them based on new data.
The Solution:	A watershed-scale strategy which takes full advantage of both point and non-point source controls in a coordinated fashion is essential to reduce nutrient loads to the maximum extent possible.

Technical reports prepared in support of the nutrient overview presented in this section of Volume II include:

- ***Appendix A*** *– Total Maximum Daily Loads (TMDL) Summary*
- ***Appendix B*** *– DEQ and EPA Response to Public Comments Received on the Volume I Document released on February 28, 2005*
- ***Appendix C*** *– GWLF/BATHTUB Modeling*
- ***Appendix E*** *– Point Sources*
- ***Appendix H*** *– Supplemental Monitoring and Assessment Strategy*
- ***Appendix I*** *– Phased Wasteload Allocation Strategy*

3.2.1 The Nutrient Problem and Water Bodies of Concern

Nutrients are essential for plant and animal growth and nourishment, but an overabundance of certain nutrients in water can cause a number of adverse health and ecological effects. Eutrophication is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth (algae, periphyton attached algae, and nuisance plants/weeds). Eutrophication caused by excessive nutrients in water can result in a variety of water-quality problems, including fish kills, noxious tastes and odors, clogged pipelines, and restricted recreation.

Based on the results presented in Volume I, nutrient problems currently exist in the water bodies listed below and shown on Figure 3-3.

- Prickly Pear Creek (MT41I006_030)
- Prickly Pear Creek (MT41I006_020)
- Sevenmile Creek (MT41I006_160)
- Spring Creek (MT41I006_080)
- Tenmile Creek (MT41I006_143)
- Lake Helena (MT41I007_010)

In general, nuisance levels of algae, high nutrient concentrations, and low dissolved oxygen have been documented in these water bodies. Volume I provides details regarding the degree of impairment and how the impairments are manifested in each of the water bodies. Additionally, if no actions are taken to curb nutrient loading and population growth continues to increase at current/projected rates within the watershed, total nitrogen (TN) and total phosphorus (TP) loading to Lake Helena is estimated to increase by 43 and 78 percent, respectively, in the foreseeable future (see Appendix C).

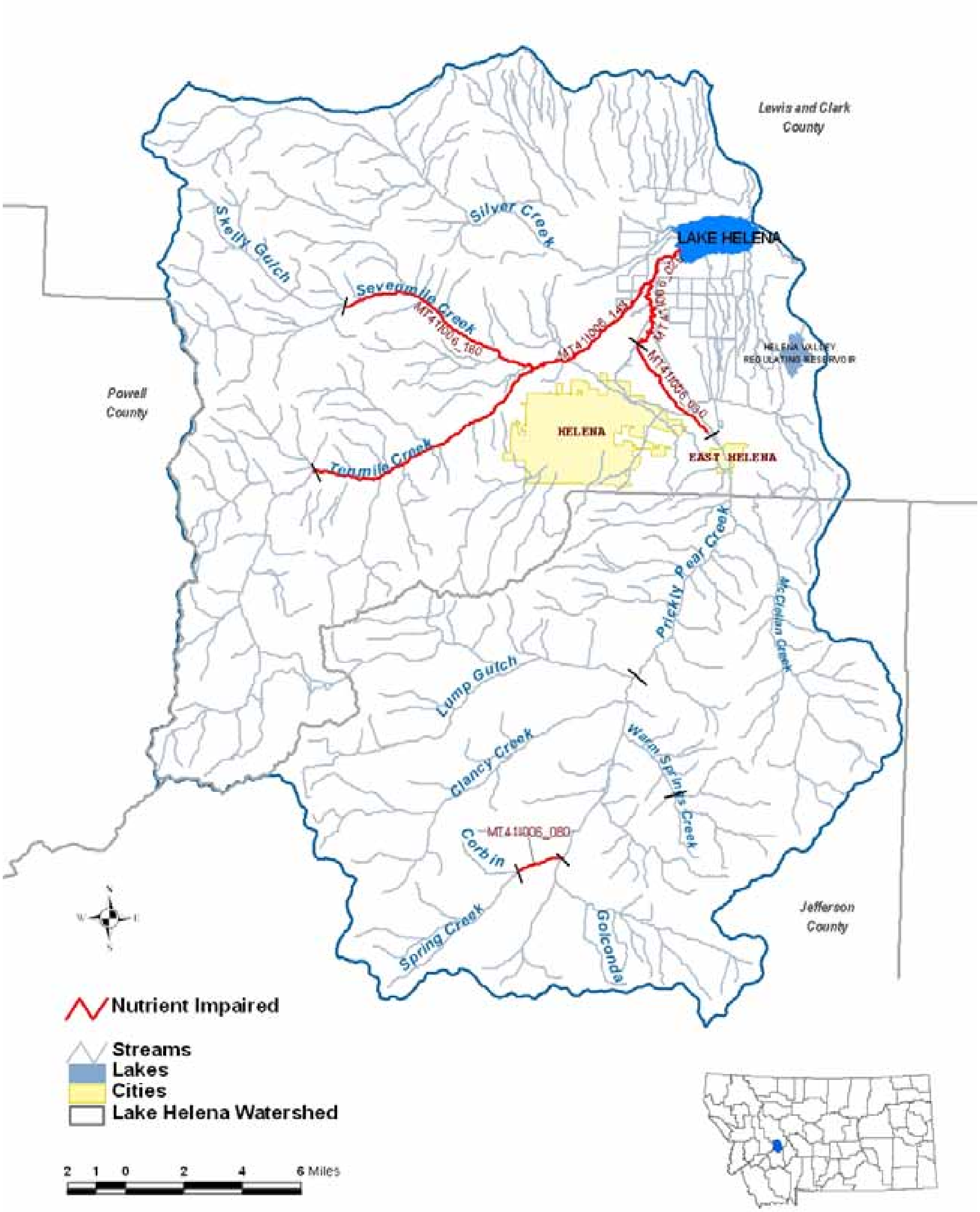


Figure 3-3. Streams in the Lake Helena watershed impaired by nutrients.

3.2.2 Nutrient Sources

The GWLF model was used to estimate the relative importance of nutrient loading from each of the nutrient source categories listed in Table 3-3 (see Appendix C for a detailed account of the nutrient modeling process and definition of source categories). Since nothing can be done to control loading from the natural sources listed in Table 3-3, they are not discussed further.

Table 3-3. Potential nutrient source categories considered in the analysis.

Category	Source
Point Sources	City of Helena WWTP (pre- and post upgrades), East Helena WWTP, Evergreen Nursing Facility, Treasure State, Tenmile and Pleasant Valley, Mountain View, Fort Harrison
Anthropogenic Nonpoint Sources	Timber Harvest, Dirt Roads, Non-system Roads, Paved Roads, Active mines and quarries, Abandoned Mines, Agriculture, Urban Areas (includes storm water – permitted and non-permitted), Anthropogenic Streambank Erosion, Helena Valley Irrigation System, Groundwater, Septic Systems
Natural Nonpoint Sources	Forest, Wetlands, Shrubland, Grassland, Natural Streambank Erosion

The relative importance of the various nitrogen and phosphorus sources in the Lake Helena Watershed is shown in Figure 3-4 and Figure 3-5. The estimates of source loading were made using the best available data and tools, but it is recognized that there is considerable uncertainty inherent within a source quantification effort such as this. For example, only one weather station (at the Helena Airport in the valley) was available to estimate precipitation throughout the entire watershed area. Although elevation effects on precipitation and temperature were accounted for on a subwatershed scale, the weather patterns are more variable in the valley compared to the upper elevations and therefore stream flow is under predicted in dry years and over predicted in wet years. Other areas of uncertainty include: estimate of timber harvest on private land, fate and transport of wastewater treatment plant nutrient loads, proportion of failing septic systems, and soil nutrient concentrations. Despite this uncertainty, the results are believed to be reasonable and appropriate for development of a framework TMDL in combination with the adaptive management strategy provided in Section 3.2.3.1 .

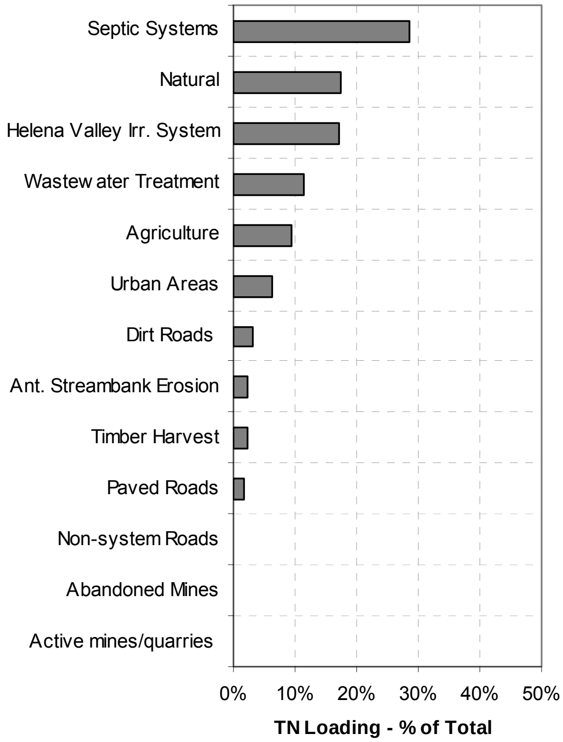


Figure 3-4. Total nitrogen (TN) loading by source category for the entire Lake Helena watershed.

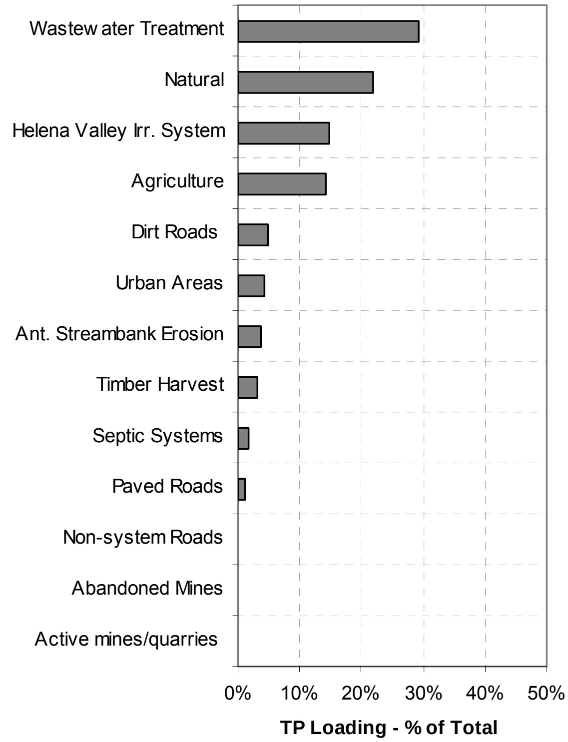


Figure 3-5. Total phosphorus (TP) loading by source category for the entire Lake Helena watershed.

At the watershed scale (i.e., the entire Lake Helena Watershed), septic systems (28 percent), return flows from the Helena Valley Irrigation System (17 percent), municipal wastewater treatment facilities (11 percent), and urban areas (6 percent) comprise the most significant sources of total nitrogen (TN). For total phosphorus (TP), municipal wastewater treatment facilities (29 percent), return flows from the Helena Valley Irrigation System (15 percent), agriculture (14 percent), dirt roads (5 percent), and urban areas (4 percent) comprise the most significant sources.

The individual streams considered impaired due to nutrients (Spring Creek, Tenmile Creek, Sevenmile Creek, and Prickly Pear Creek) are all within the Prickly Pear Creek sub-watershed. The relative importance of the various nutrient sources within the Prickly Pear Creek sub-watershed is shown in Figures 3-6 and 3-7. Discharges of both TN and TP from municipal wastewater treatment facilities are far more important at the scale of the Prickly Pear Creek sub-watershed than they are at the scale of the entire Lake Helena Watershed. For example, the municipal wastewater treatment facilities are the largest contributors of both TN and TP to Prickly Pear Creek and have the greatest impact in the most downstream segment (i.e., downstream of the City of Helena WWTP). For TN, septic systems, urban areas, and agriculture are the next most important sources. For TP, agriculture, dirt roads, and stream bank erosion are the next most significant sources. While the Helena Valley Irrigation System is one of the most significant sources of both TN and TP to Lake Helena, this source does not directly discharge to Prickly Pear Creek and therefore is not an important source at the sub-watershed scale.

The relative importance of the various TN and TP sources in the sub-watersheds of the remaining nutrient impaired streams is discussed in Appendix A.

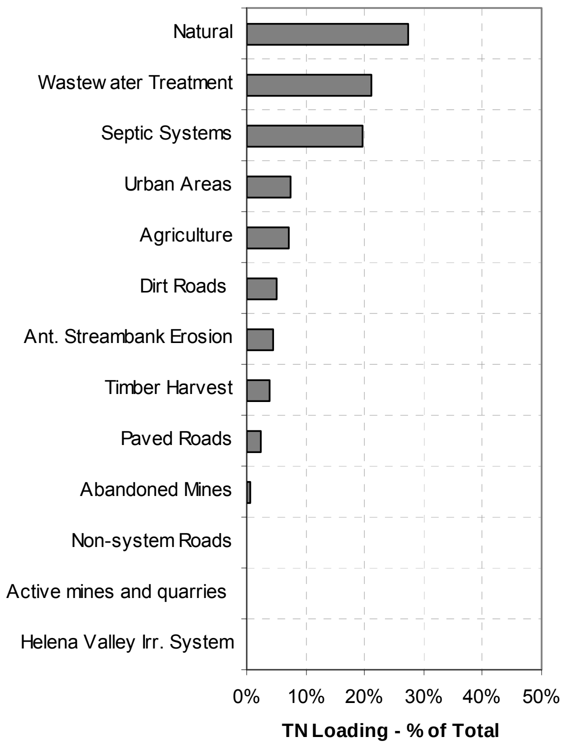


Figure 3-6. Total nitrogen loading by source category for the Prickly Pear Creek sub-watershed.

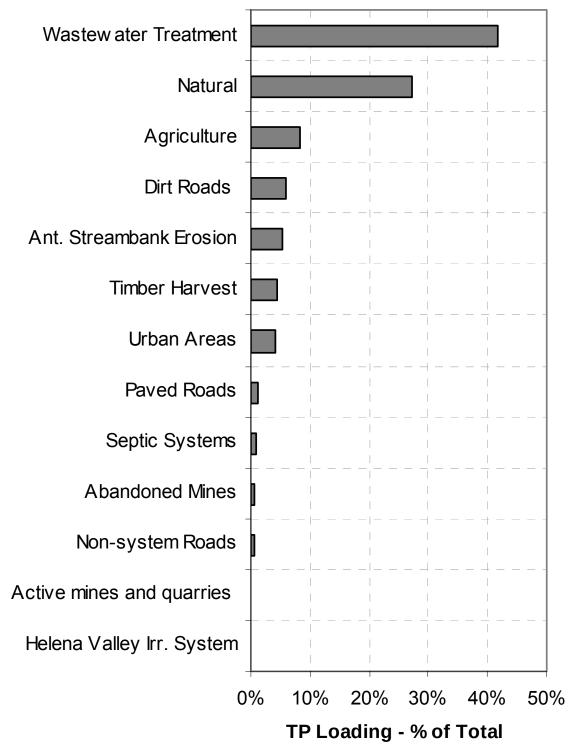


Figure 3-7. Total phosphorous loading by source category for the Prickly Pear Creek sub-watershed.

3.2.3 Nutrient Goals

Similar to sediment, Montana's water quality standards for nutrients are narrative and, therefore, must be interpreted to derive measurable water quality goals. A suite of measurable nutrient indicators was developed and described in Volume I to facilitate interpretation of the narrative nutrient standards for streams. This suite of indicators was selected based on the best data and information available when Volume I was completed. As a parallel but separate effort, Montana DEQ has been working on the development of numeric standards for nutrients for approximately the last four years and recently developed draft criteria. A comparison between the various potential nutrient criteria is presented in Table 3-4. Overall, the analysis shows that the values are all relatively similar.

Table 3-4. Potential nutrient criteria for the Lake Helena watershed streams.

Parameter	Values Proposed in Volume I (year round)	Draft MDEQ Summer Values[1]		Draft MDEQ Year-round Values	
		75th Percentile	90th Percentile	75th Percentile	90th Percentile
Total Nitrogen (mg/l)	0.34	0.32	0.33	0.27	0.33
Total Phosphorus (mg/l)	0.027	0.01	0.02	0.02	0.04
Benthic Chlorophyll a (mg/m^2)	37	23.36	45.95	22.97	45.95

[1]The values in these columns represent statistical summaries of nitrogen and phosphorus concentrations and benthic algal chlorophyll a densities for reference streams in the Middle Rockies ecoregion (ICF, 2005).

Both sets of values (those presented in Volume I and those developed by MDEQ) were developed using a reference-based approach based on USEPA's recommended methodology. USEPA, in their Nutrient Criteria Technical Guidance Manual (USEPA, 2000), suggests that the 75th percentile value from a large reference data set can be used to establish criteria. The year-round Volume I nutrient targets and the MDEQ 75th percentile values are nearly identical. Given that they were derived independently from one another provides additional confidence in the values. However, given the historic landscape scale changes that have occurred in the Lake Helena watershed over the last 100 to 150 years (see Section 3.0), it is acknowledged that it may not be technically or economically feasible to attain these nutrient values. For example, the TN and TP loads would need to be reduced by approximately 80 and 87 percent, respectively, to achieve the least restrictive values presented in Table 3-4.

Given this uncertainty, final nutrient targets are not presented herein. Rather, interim nutrient targets are proposed for the streams in the Lake Helena Watershed **in combination** with an adaptive management strategy to revise them in the future. The draft MDEQ 90th year-round percentile values presented in Table 3-4 are proposed as the interim targets. It is felt that these targets are based on the best available data and provide the best means by which to ensure protection of beneficial uses until such time as they can be revised following the adaptive management strategy presented below.

No nutrient concentration targets are presented for Lake Helena at this time due to limited historic water quality data and an incomplete understanding of the hydrologic relationship between Lake Helena and Hauser Reservoir (see Appendix A and Appendix B). Interim nutrient loading goals, however, are proposed in Section 3.2.4.

3.2.3.1 Adaptive Management Applied to the Nutrient Targets

An adaptive management strategy is proposed to facilitate revision of the nutrient threshold values for the streams in the Lake Helena watershed and to derive threshold values for Lake Helena (and possibly Hauser Reservoir). This strategy combines and coordinates supplemental study elements with regulatory elements.

> **Adaptive Management Strategy for Nutrients**
>
> The adaptive management strategy for nutrients has been developed to refine our understanding of the relationship between nutrient loading and impacts to beneficial uses in the streams and lakes in the Lake Helena Watershed. Once the supplemental study elements presented in Section 3.2.3.2 are completed, sufficient data and information will be available to determine the nutrient threshold, above which, beneficial uses would be impacted in the streams and lakes (the science). The alternatives analysis/feasibility study to be conducted by the point source nutrient dischargers will determine the maximum level of treatment that can be provided through wastewater treatment and the associated costs (technology and economics).
>
> At the same time the above elements are ongoing, Montana has begun the process to develop and adopt numeric nutrient standards on a statewide basis. Montana's process will ultimately unfold as a formal rule making process including scientific, technologic, and economic analyses, public involvement/comment and adoption by the Montana Board of Environmental Review.
>
> At the scale of the Lake Helena Watershed, the "scientific" and "technological/economic" information complied through the supplemental studies, and alternatives analysis conducted by point source dischargers will be factored into the State's formal rule making process to adopt numeric standards for nutrients that would be applicable to the Lake Helena Watershed.
>
> Once the numeric standards are adopted, the interim targets presented in this document will be revised to reflect them. Further, the plans for reducing both point source and non-point source nutrient loads will also be revised to reflect them.

3.2.3.2 Supplemental Study Elements

The supplemental study elements include both additional monitoring and modeling. A detailed monitoring strategy – outlined in Appendix H – is proposed to:

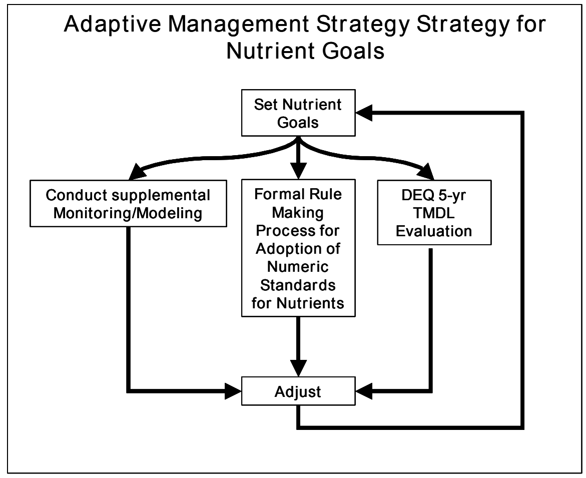
- Better characterize current water quality conditions in Prickly Pear Creek, Lake Helena and Hauser Lake.
- Compile sufficient data for future model calibration.
- Develop an understanding of the relationship between nutrient loading and stream/lake response (i.e., what is the threshold above which beneficial uses are impaired).
- Develop an understanding of the hydrologic connection between Lake Helena, the "Causeway Arm" of Hauser Lake, and Hauser Lake in general.

Additional modeling is also proposed to allow for a more direct understanding of the link between in-stream nutrient concentrations, environmental variables, and biotic response. The current GWLF and BATHTUB models are set up at a relatively coarse scale to provide information at the annual or monthly time period (see Appendix C). Daily and/or even hourly simulations are required to observe water body response to nutrients. The LSPC model has already been set up at the watershed scale to address metals issues (see Section 3.3 and Appendix F) and has the capability of simulating finer time steps and algal response in streams, assuming sufficient calibration data are available. For example, LSPC could be used to simulate hourly dissolved oxygen concentrations to determine how reduced benthic algae would lead to higher dissolved oxygen minimums. With this in mind, it is recommended that future activities for Lower Prickly Pear Creek involve additional sampling and data collection to allow the LSPC model to evaluate nutrient issues.

EPA/MDEQ propose to initiate the supplemental study elements in 2006, contingent upon availability of funding and appropriate resources.

3.2.3.3 Regulatory Elements

There are two primary regulatory mechanisms through which targets and TMDLs may be modified in the future: 1) Montana Code Annotated 75-5-703(9)(c) provides a provision for revising the TMDL based on an evaluation conducted by MDEQ five years after the TMDL is completed and approved, and 2) MDEQ has begun the initial steps of numeric standards development for nutrients. MDEQ expects to start the formal rule making process for adoption of numeric standards within the next 2 years. Prior to the start of formal rulemaking, MDEQ will provide opportunity for informal public comment, as well as for the formal public comment prescribed under statute.



The current "use classification" for lower Prickly Pear Creek drives the final adaptive management element relative to nutrients. Prickly Pear Creek, from Highway 433 to Lake Helena is currently classified as an "I" stream. Streams classified as "I" are not currently supporting all of their designated uses, but ultimate attainment of these uses is the goal of the State of Montana. The ultimate goal for Prickly Pear Creek is to attain full support of all of the designated uses associated with the underlying use classification for the remainder of the stream (i.e., B-1).

It is envisioned that all of the above elements will provide both the data and information needed to revise the proposed nutrient goals (if appropriate), provide a regulatory framework within which the revisions could occur, and also will provide for public participation.

3.2.4 The Solution

The solution to the nutrient problem is to immediately begin reducing nutrient loads from all sources (both point and non-point). The necessary nutrient load reductions for Prickly Pear Creek, Tenmile Creek, Sevenmile Creek, Spring Creek, and Lake Helena, using the interim targets, are shown in Table 3-5. Since no concentration targets have been proposed for Lake Helena at this time, it is assumed that the load reductions for Prickly Pear Creek (the largest tributary to Lake Helena) adequately approximate the necessary load reductions for Lake Helena. TMDLs have been prepared for each of these water bodies and the source specific load reductions are presented in Appendix A.

The proposed approach acknowledges that it may be necessary to revise the nutrient concentration values in the future **AND** provides an adaptive management strategy to revise them. It is also acknowledged that beneficial uses are already impaired and conditions are predicted to deteriorate further if nothing is done to begin to curb nutrient loading.

Table 3-5. Current nutrient loads and necessary reductions in the Lake Helena watershed.

Watershed	Estimated Total Nitrogen Load (tons/yr)	Reduction Required to meet 0.33 mg/l Total Nitrogen Goal	Estimated Total Phosphorus Load (tons/yr)	Reduction Required to meet 0.04 mg/l Total Phosphorus Goal
Prickly Pear Creek	181.72	80	34.04	87
Sevenmile Creek	15.40	65	2.33	79
Spring Creek	7.51	75	1.32	83
Tenmile Creek	56.73	59	7.11	61
Lake Helena	352.08	80[1]	51.09	87[1]

[1]In the absence of appropriate water quality targets for Lake Helena, the load reductions for Prickly Pear Creek (the largest tributary watershed to Lake Helena) are assumed to also be necessary for Lake Helena.

A phased approach, focusing on both non-point and point sources is proposed. As shown in Figure 3-8, the proposed approach has been coordinated, in time, with point source discharge permit renewals and the rule making process for adoption of numeric standards for nutrients. This approach combines elements described previously in the main document and/or in various appendices. Table 3-6 provides a list of each of the basic steps of the approach, a brief description, and references to detailed descriptions of each of the activities.

Table 3-6. Chronological order of point and non-point source activities to reduce nutrient loading (dates are tentative).

Year	Implementation Activity	Description
2006	Complete and approve TMDLs and establish interim nutrient targets	See Section 3.2.3
	Implement supplemental monitoring/modeling study	See Section 3.2.3.1
	Implement voluntary non-point source controls	See Appendix A for source specific load reductions and Section 4.0
	Implement voluntary point source monitoring	See Appendix I
	Implement voluntary point source optimization and feasibility studies	See Appendix I
	Implement voluntary Phase I point source controls	See Appendix I
	MDEQ technical analyses in support of nutrient standards development	See Section 3.2.3.1
	Initiation of formal rule making process to adopt numeric nutrient standards	See Section 3.2.3.1
2008	MBER officially adopts numeric nutrient standards	See Section 3.2.3.1
	Revise TMDL and targets to incorporate numeric nutrient standards	Once numeric nutrient standards are officially adopted, the nutrient TMDLs and targets will be revised.
2009	MDEQ renews MPDES permits for Helena and East Helena	See Appendix I
	Implement Phase II point source controls based on optimization study results	See Appendix I
2014	MDEQ renews MPDES permits for Helena and East Helena	See Appendix I
	Implement Phase III point source controls based on numeric nutrient standards and results of feasibility study	See Appendix I

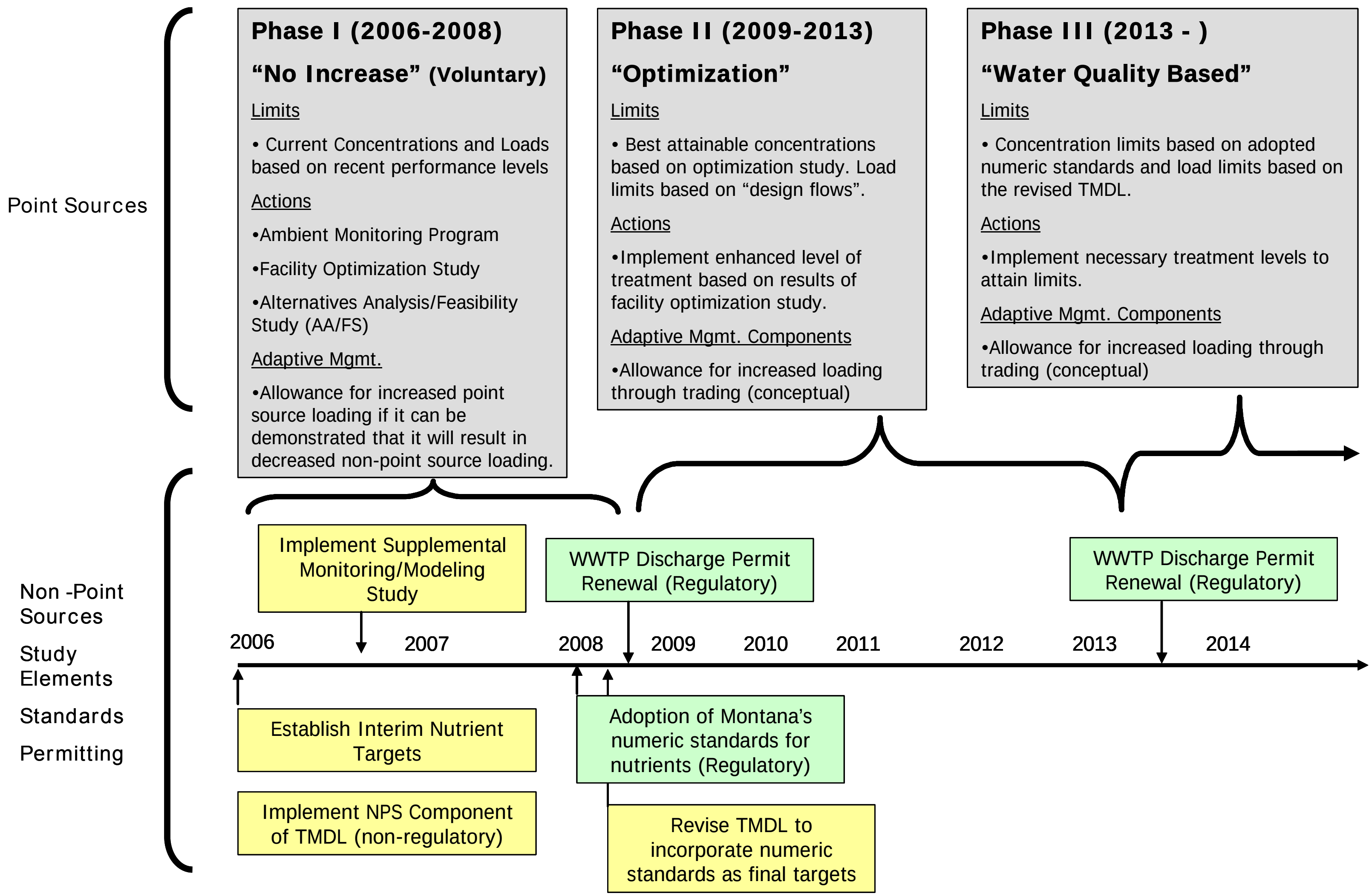


Figure 3-8. Coordinated implementation schedule for point and non-point source nutrient reduction strategy (all dates are tentative).

3.3 METALS

The Problem:	High in-stream concentrations of certain metals (e.g., arsenic, cadmium, copper, lead, and zinc) exceed levels that are considered protective of aquatic life and/or human health. Streambed-sediment and fish tissue metals concentrations are also elevated in certain parts of the watershed.
Water Bodies of Concern:	Clancy Creek, Corbin Creek, Golconda Creek, Jennie's Fork, Lump Gulch, Middle Fork Warm Springs Creek, North Fork Warm Springs Creek, Prickly Pear Creek, Tenmile Creek, and Warm Springs Creek.
The Source:	Mining and mine drainage, particularly from abandoned mines, are considered the primary source of metals within the watershed. Metals are also associated with the erosion of sediments from other sources.
In-Stream Metals Goals:	Achieve numeric criteria established in water quality standards.
The Solution:	A watershed scale strategy that incorporates both point and non-point source reductions to achieve water quality standards in all waterbodies in the Lake Helena watershed.
Technical reports prepared in support of the metals overview presented in this section of Volume II include: • ***Appendix A*** *– Total Maximum Daily Loads (TMDL) Summary* • ***Appendix E*** *– Point Sources* • ***Appendix F*** *– LSPC Metals Modeling* • ***Appendix H –*** *Supplemental Monitoring and Assessment Strategy*	

3.3.1 The Metals Problem and Water Bodies of Concern

Metals are naturally occurring in streams and lakes, originating from local geology, soils, and groundwater. Anthropogenic sources, such as industrial point sources, mines, mine drainage, soil erosion (from roads, agriculture, timber harvest, etc.), air deposition, and urban and road runoff can increase metal concentrations in streams to toxic levels. Numerous studies have shown that metals, often at very low concentrations, can be toxic to humans, fish, and aquatic life health. A summary of the toxic effects of six metals of concern – arsenic, cadmium, copper, lead, mercury, and zinc – is shown below (summarized from, "Information on the Toxic Effects of Various Chemicals and Groups of Chemicals," USEPA, 2005).

- **Arsenic –** Arsenic is a carcinogen (cancer-causing), teratogen, and possible mutagen (causing mutations in genes/DNA) in mammals (ATSDR 1993). Cancer-causing and genetic mutation-causing effects occur in aquatic organisms, with those effects including behavioral impairments, growth reduction, appetite loss, and metabolic failure. Aquatic bottom feeders are more susceptible to arsenic.
- **Cadmium –** Cadmium is highly toxic to wildlife; it is cancer-causing and teratogenic and potentially mutation-causing, with severe sublethal and lethal effects at low environmental concentrations (Eisler 1985a). It is associated with increased mortality, and it affects respiratory functions, enzyme levels, muscle contractions, growth reduction, and reproduction. It bioaccumulates at all trophic levels, accumulating in the livers and kidneys of fish (Sindayigaya, et al. 1994; Sadiq 1992). Crustaceans appear to be more sensitive to cadmium than fish and mollusks (Sadiq 1992).
- **Copper –** Copper is highly toxic in aquatic environments and has effects in fish, invertebrates, and amphibians, with all three groups equally sensitive to chronic toxicity (USEPA 1993; Horne and Dunson 1995). Copper will bioconcentrate in many different organs in fish and mollusks (Owen 1981). Single-cell and filamentous algae and cyanobacteria are particularly susceptible to the acute effects, which include reductions in photosynthesis and growth, loss of photosynthetic pigments, disruption of potassium regulation, and mortality. Sensitive algae may be affected by free copper at low (parts per billion) ppb concentrations in freshwater. There is a moderate potential for bioaccumulation in plants and no biomagnification.
- **Lead –** Lead is cancer-causing, and adversely effects reproduction, liver and thyroid function, and disease resistance (Eisler 1988b). The main potential ecological impacts of wetland contaminants result from direct exposure of algae, benthic invertebrates, and embryos and fingerlings of freshwater fish and amphibians to lead. It can be bioconcentrated from water, but does not bioaccumulate and tends to decrease with increasing trophic levels in freshwater habitats (Wong et al. 1978; Eisler 1988b). Fish exposed to high levels of lead exhibit a wide-range of effects including muscular and neurological degeneration and destruction, growth inhibition, mortality, reproductive problems, and paralysis (Eisler 1988b; EPA 1976). Lead adversely affects invertebrate reproduction; algal growth is affected.
- **Mercury –** Mercury is a mutagen (mutation-causing), teratogen, and carcinogen (cancer-causing), with toxicity and environmental effects varying with the form of mercury, dose, and route of ingestion, and with the exposed organism's species, sex, age, and general condition (Eisler, 1987a, Fimreite 1979). There is a high potential for bioaccumulation and biomagnification with mercury, with biomagnified concentrations reported in fish up to 100,000 times the ambient water concentrations (Eisler 1987a, Callahan et al. 1979). The primary targets of acute exposures are the central nervous system and kidneys in fish, birds and mammals. There are also effects on reproduction, growth, behavior, metabolism, blood chemistry, osmoregulation, and oxygen exchange at relatively low concentrations of mercury (Eisler 1987a). Juveniles are commonly more susceptible than adults.

- **Zinc –** In many types of aquatic plants and animals, growth, survival, and reproduction can all be adversely affected by elevated zinc levels (Eisler 1993). Zinc is toxic to plants at elevated levels, causing adverse effects on growth, survival, and reproduction (Eisler 1993). Terrestrial invertebrates show sensitivity to elevated zinc levels, with reduced survival, growth, and reproduction. Elevated zinc levels can cause mortality, pancreatic degradation, reduced growth, and decreased weight gain in birds (Eisler 1993; NAS 1980); and elevated zinc can cause a wide range of problems in mammals including: cardiovascular, developmental, immunological, liver and kidney problems, neurological, hematological (blood problems), pancreatic, and reproductive (Eisler 1993; Domingo 1994).

To protect beneficial uses from metals toxicity, Montana DEQ has set numeric water quality standards to protect both acute and chronic exposure. Based on the analysis presented in Volume I, metals are currently exceeding the Montana DEQ water quality standards in thirteen stream segments and one lake in the Lake Helena watershed. The impaired segments include Clancy Creek, Corbin Creek, Golconda Creek, Jennie's Fork, Lake Helena, Lump Gulch, Middle Fork Warm Springs Creek, North Fork Warm Springs Creek, Prickly Pear Creek, Sevenmile Creek, Silver Creek, Spring Creek, Tenmile Creek, and Warm Springs Creek (Figure 3-9). Table 3-7 lists the metals that are exceeding standards in each waterbody.

Table 3-7. Streams in the Lake Helena watershed impaired by metals.

Water Body Name	Segment ID	Metals of Concern
Clancy Creek	MT41I006_120	Arsenic, Cadmium, Copper, Lead, And Zinc
Corbin Creek	MT41I006_090	Arsenic, Cadmium, Copper, Lead, And Zinc
Golconda Creek	MT41I006_070	Cadmium And Lead
Jennie's Fork	MT41I006_210	Lead
Lake Helena	MT41I007_010	Arsenic And Lead
Lump Gulch	MT41I006_130	Cadmium, Copper, Lead, And Zinc
Middle Fork Warm Springs Creek	MT41I006_100	Arsenic, Cadmium, Lead, And Zinc
North Fork Warm Springs Creek	MT41I006_180	Arsenic, Cadmium, And Zinc
Prickly Pear Creek	MT41I006_020	Arsenic, Cadmium, And Lead
	MT41I006_030	Arsenic And Lead
	MT41I006_040	Arsenic, Cadmium, Copper, Lead, And Zinc
	MT41I006_050	Cadmium, Lead, And Zinc
	MT41I006_060	Lead
Sevenmile Creek	MT41I006_160	Copper, Lead And Arsenic
Silver Creek	MT41I006_150	Arsenic And Mercury
Spring Creek	MT41I006_080	Arsenic, Cadmium, Copper, Lead, And Zinc
Tenmile Creek	MT41I006_141	Arsenic, Cadmium, Copper, Lead, And Zinc
	MT41I006_142	Arsenic, Cadmium, Copper, Lead, And Zinc
	MT41I006_143	Arsenic, Cadmium, Copper, Lead, And Zinc
Warm Springs Creek	MT41I006_110	Arsenic, Cadmium, Lead, And Zinc

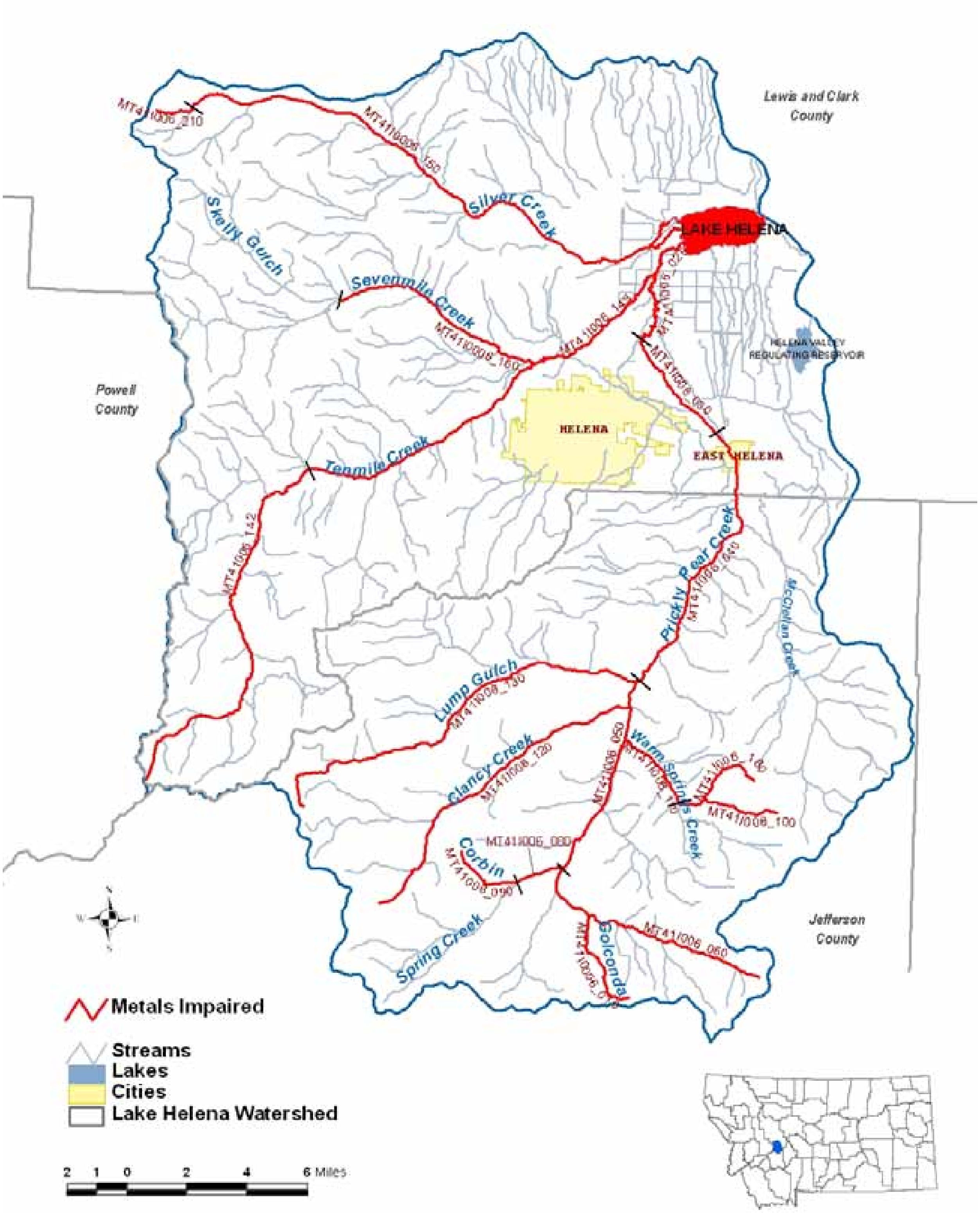


Figure 3-9. Streams in the Lake Helena watershed impaired by metals.

3.3.2 Metals Sources

The LSPC model was used to estimate the relative importance of metals loading from each of the source categories listed in Table 3-8 (see Appendix F for a detailed account of the metals modeling process and definition of source categories).

Table 3-8. Potential metals source categories considered in the analysis.

Category	Source
Point Sources	MT Tunnels Mines
	ASARCO Smelter
Anthropogenic Nonpoint Sources	Abandoned Mines
	Anthropogenic Streambank Erosion
	Timber Harvest
	Dirt Roads
	Non-system Roads
	Paved Roads
	Active mines and quarries
	Agriculture
	Urban Areas
Natural Nonpoint Sources	Forest
	Wetlands
	Shrubland
	Grassland
	Nat. Streambank Erosion

The relative importance of the source categories, at the entire Lake Helena watershed scale, is shown in Figures 3-10 to 3-14. The estimates of loading from each source category were made using the best available data and tools, but it is recognized that there is considerable uncertainty inherent within a source quantification effort such as this. Despite this uncertainty, the results are believed to be reasonable and appropriate for proceeding with development of a framework TMDL in combination with the adaptive management (see Appendix F).

At the time of this report, insufficient data are available to accurately quantify mercury loads in Silver Creek, Clancy Creek, Lump Gulch, Middle Fork Warm Springs Creek, and Tenmile Creek. There is also little fish and aquatic life data available to assess the potential impacts of historic mercury loading and bioaccumulation. Additional monitoring is recommended (see Appendix H) to better address these loads in the future, at which time the mercury TMDLs will be completed.

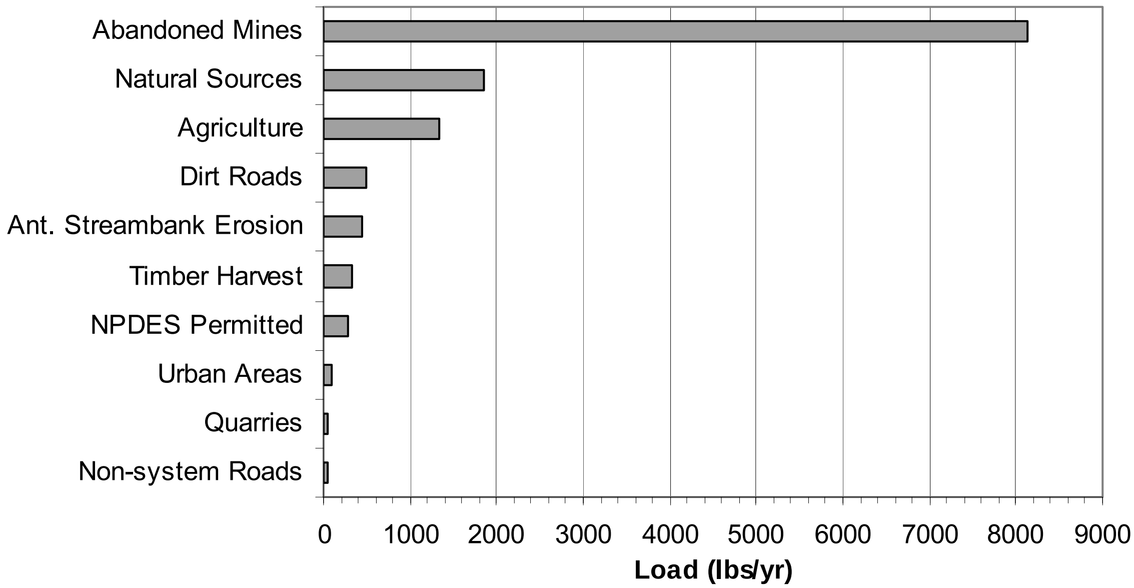


Figure 3-10. Estimated sources of arsenic in the entire Lake Helena watershed.

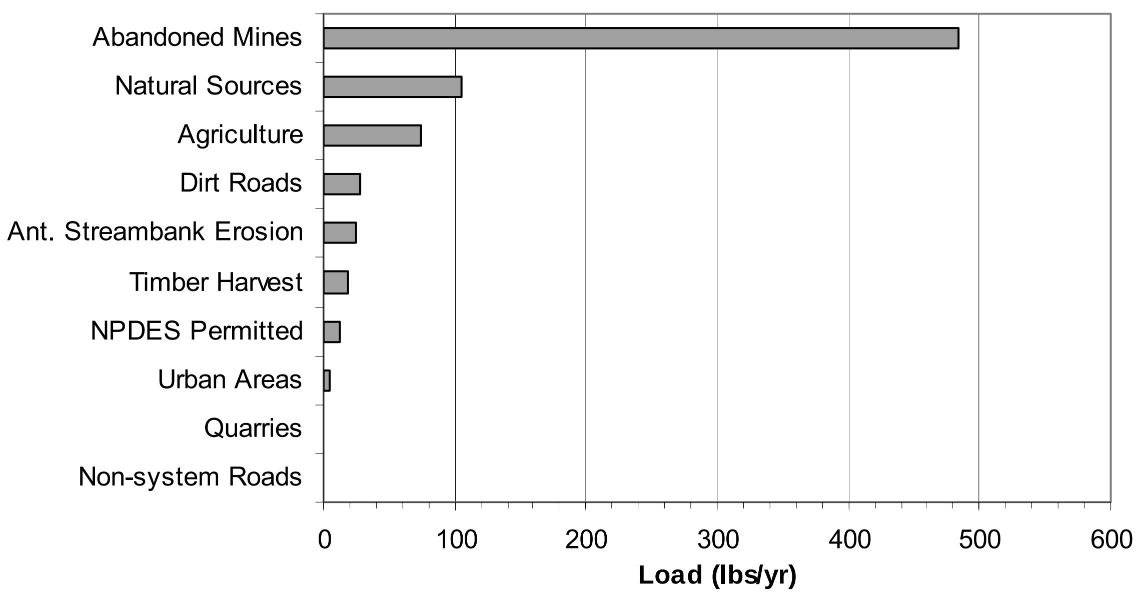


Figure 3-11. Estimated sources of cadmium in the entire lake Helena watershed.

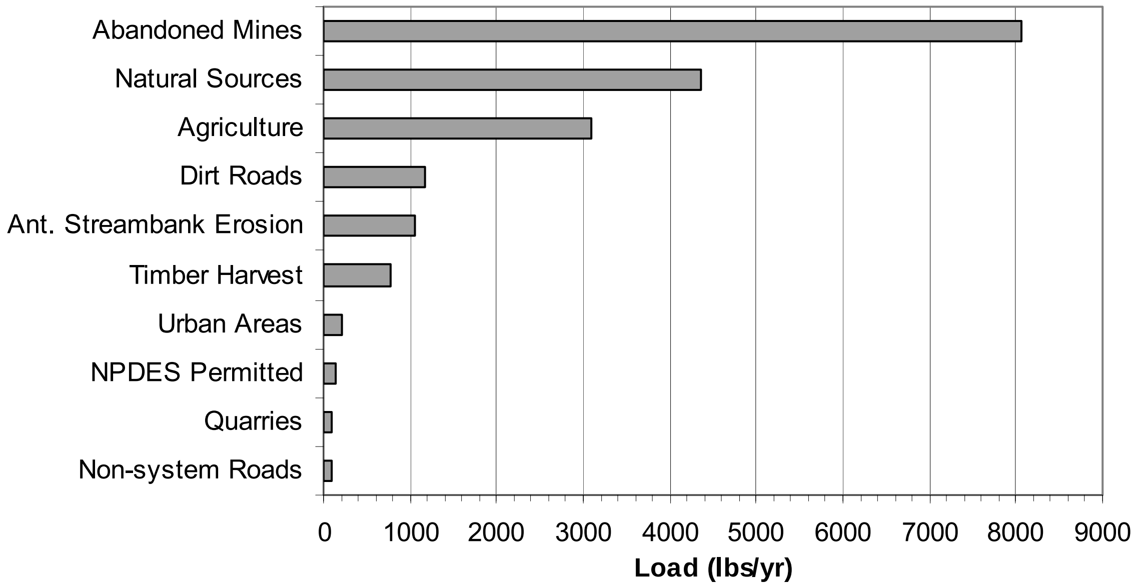


Figure 3-12. Estimated sources of copper in the entire lake Helena watershed.

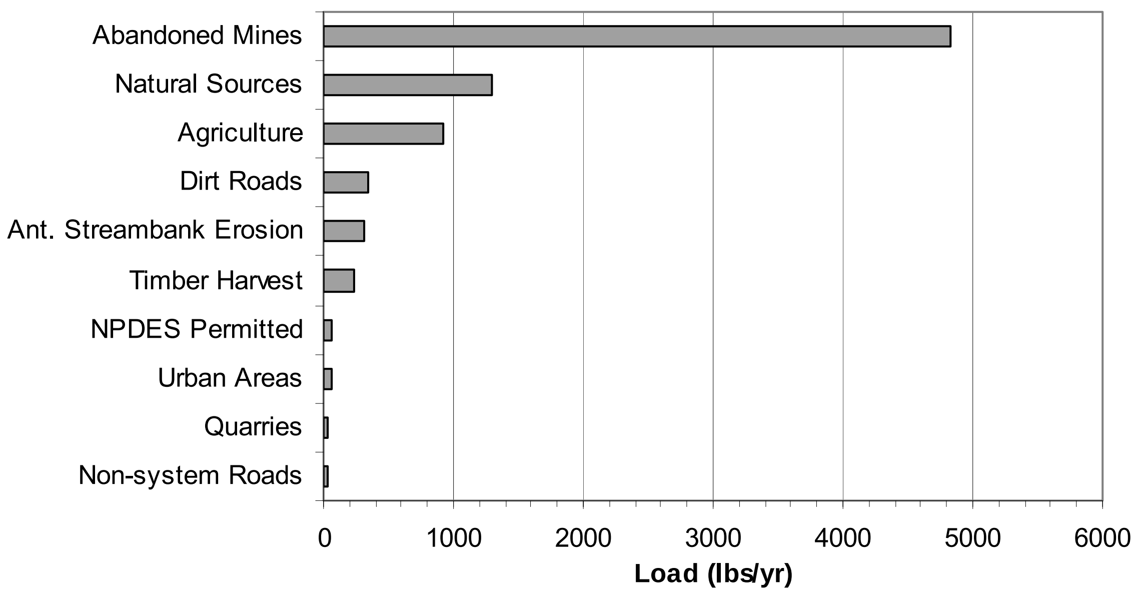


Figure 3-13. Estimated sources of lead in the entire lake Helena watershed.

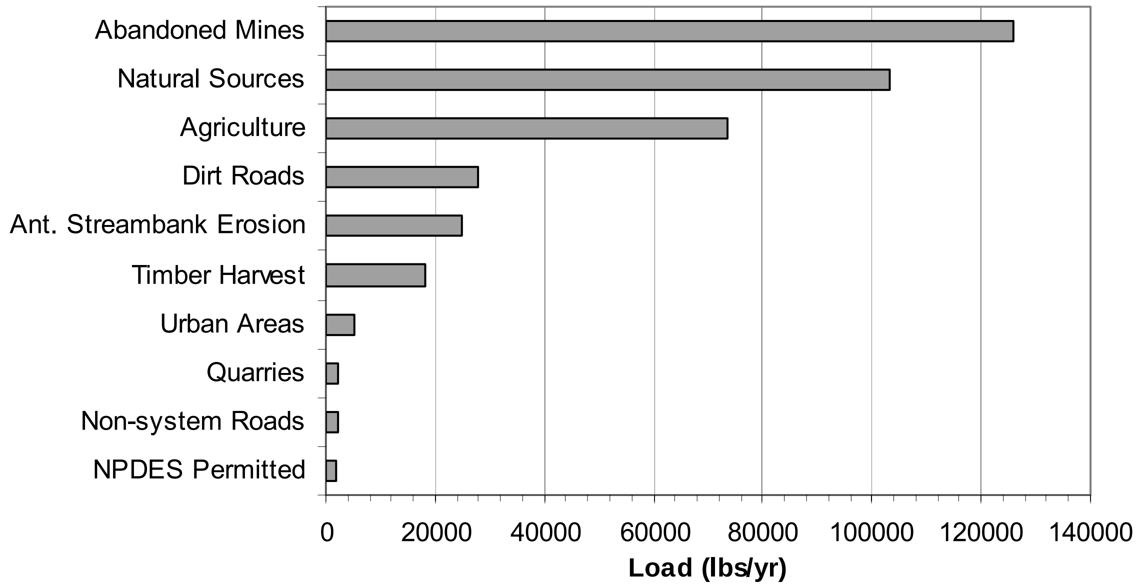


Figure 3-14. Estimated sources of zinc in the entire Lake Helena watershed.

At the watershed scale (i.e., the entire Lake Helena Watershed), abandoned mines are the most significant source of all metals. Natural sources (e.g., forest and grassland areas) and agriculture are the next most important sources, primarily because of the sediment-associated metals they deliver to the streams. It should also be noted that agriculture is estimated to be a significant source of metals at the watershed scale (due to the extensive agricultural areas in the Lake Helena Valley), but not at the headwater individual stream scale where most metals impairments are located.

The individual streams considered impaired due to metals are found throughout the watershed. Each of the three largest streams (Prickly Pear Creek, Tenmile Creek, and Sevenmile Creek) is impaired, as are various tributaries. Abandoned mining is estimated to be the most significant source of metals for each listed waterbody. The relative importance of the various metals sources in the sub-watersheds is discussed in Appendix A.

3.3.3 Metals Goals

Unlike sediment and nutrients, Montana's water quality standards for metals are numeric and, therefore, can be directly applied as water quality goals.

The *Circular WQB-7, Montana Numeric Water Quality Standards* contains numeric water quality standards for Montana's surface water and groundwater. The standards in Circular WQB-7 are set at the levels necessary to protect the uses of the waters. They are based on the best available scientific evidence relating the concentration of pollutants to effects on aquatic life and human health. These numeric standards are used as TMDL targets for metals.

There are three numeric standards for each metal: acute and chronic toxicity aquatic life standards designed to protect aquatic life uses, and the human health standard, designed to protect drinking water uses[1]. Table 3-9 shows the acute and chronic aquatic life standards and the human health standards applicable to the metals of concern in the Lake Helena watershed. Both the acute and chronic aquatic life standards for cadmium, copper, lead, and zinc are hardness-dependent. The criteria are calculated using the formulas can be found in the Montana DEQ Circular WQB-7. An average hardness for each impaired stream segment was determined from the observed data and used to identify the appropriate target for TMDL development. The average hardness and resulting numeric target are presented in Appendix A.

Table 3-9. Montana numeric surface water quality standards for metals.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10 [d]
Cadmium (TR)	1.05 at 50 mg/L hardness[c]	0.16 at 50 mg/L hardness[c]	5
Copper (TR)	7.3 at 50 mg/L hardness[c]	5.2 at 50 mg/L hardness[c]	1,300
Lead (TR)	82 at 100 mg/L hardness[c]	3.2 at 100 mg/L hardness[c]	15
Zinc (TR)	67 at 50 mg/L hardness[c]	67 at 50 mg/L hardness[c]	2,000

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L) (see Montana DEQ Circular WQB-7 for the coefficients to calculate the standard).
[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

3.3.4 The Solution

The solution to the metals impairments is to reduce metals loading throughout the Lake Helena watershed. The following steps were taken to determine the load reductions necessary to meet each component of the metals water quality standards:

1) Loads from NPDES permitted-facilities were input to the LSPC model at their allowable limits (see Appendix F). This was done to account for allowable loads (even though a facility's loads might actually be significantly less than their allowable load). *Note: the flows for these facilities are determined within the model as precipitation driven.*
2) Reductions of sediment-adsorbed metals were input to the LSPC model for each appropriate source category to account for the reductions resulting from the sediment TMDLs (see Section 3.1). The reductions were assumed to be the same for sediment and sediment-adsorbed metals.
3) Additional reductions were made to the abandoned mining source category until all three numeric standards for each metal were met. Loads were reduced until no predicted daily value exceeded the acute aquatic life or human health criteria and no 4-day average exceeded the chronic aquatic life criteria. There was no single criterion that drove all the reductions (it usually depended on the metal, and the hardness). The exception was arsenic, for which the human health criterion was the driving factor.

[1] It should be noted that recent studies have indicated some metals concentrations vary through out the day because of diel pH and alkalinity changes (USGS, 2003). In some cases the variation can cross the standard threshold (both ways) for a metal. Montana water quality standards are not time of day dependent.

4) It is recognized that the Montana Tunnels Mine (NPDES Permit MT0028428) rarely (if ever) discharges to Spring Creek. However, the TMDLs presented in this document and in Appendix A are based on the permitted flows and pollutants for all point source discharges. The Montana Tunnels Mine arsenic permit limit (290 µg/L) is currently 29 times larger than the new arsenic human health criterion (10 µg/L). To meet water quality standards in Spring Creek, the permitted arsenic load was reduced by 60 percent.

A "top-down" methodology was followed to develop the TMDL allocations. Impaired headwaters were analyzed first, because their impact frequently had a profound effect on downstream water quality. Loading contributions were reduced from the applicable sources for these waterbodies and model results from the selected successful scenarios were then routed through downstream waterbodies. Therefore, when TMDLs were developed for downstream impaired waterbodies, upstream contributions represented conditions meeting water quality standards.

TMDLs for each of the metals-impaired water bodies and the source specific load reductions are presented in Appendix A. A summary of the load reductions for each waterbody is presented in Table 3-10. Figures 3-15 to 3-19 show the necessary load reductions for the entire Lake Helena watershed broken down by source category.

The reduction for most sources (e.g., anthropogenic streambank erosion, timber harvest) is based on the anticipated reductions resulting from the sediment TMDLs (see Section 3.1). Additional load reductions that are necessary from abandoned mines range from 70 to 90 percent depending on the stream and metal. It is not yet certain whether this level of treatment for abandoned mines will be attainable for all impaired streams. Pre- and post-reclamation monitoring of a semi-passive treatment system at the Lee Mountain Mine in Upper Tenmile Creek indicates removal efficiencies as high as 90 percent are possible (personal communication, Mike Bishop, EPA Superfund, October 6, 2005). However, it might be prohibitively expensive or practically impossible to achieve this level of treatment at all sites.

In some cases alternative remedies might also be needed in addition to reducing loads from abandoned mines. For example, one restoration strategy under consideration for Upper Tenmile Creek is to bypass water through the City of Helena's Rimini diversion into Tenmile Creek. The bypass would result in less water being diverted by the city for water supply and would increase the minimum flow, essentially helping to dilute metals concentrations. A site-specific WASP modeling analysis of Upper Tenmile Creek indicates that a one to three cubic feet per second increase in stream flows during critical low flow conditions greatly increases the likelihood that water quality standards could be met (Caruso, 2004).

Table 3-10. Current metal loads and necessary load reductions in the Lake Helena watershed.

Segment	Metal	Existing Load (lbs/yr)	Load Reduction (%)	Total Allowable Load (lbs/yr)
Clancy Creek (MT41I006_120)	Arsenic	717.9	61.1%	279.3
	Cadmium	34.0	61.2%	13.2
	Copper	897.0	42.3%	517.6
	Lead	339.0	54.1%	155.6
	Zinc	20,038.9	47.0%	10,620.6
Corbin Creek (MT41I006_090)	Arsenic	48.4	24.7%	36.2
	Cadmium	87.7	96.8%	2.8
	Copper	1058.5	89.2%	114.6
	Lead	97.4	65.9%	33.2
	Zinc	58,393.2	97.2%	1,660.6
Golconda Creek (MT41I006_070)	Cadmium	1.1	40.9%	0.7
	Lead	27.2	76.9%	6.3
Jennie's Fork (MT41I006_210)	Lead	15.5	45.7%	8.4
Lake Helena (MT41I007_010)	Arsenic	13,032.2	60.8%	5,104.2
	Lead	8,134.6	65.6%	2,798.0
Lump Gulch (MT41I006_130)	Cadmium	43.9	76.1%	10.4
	Copper	745.9	39.3%	452.8
	Lead	241.3	43.9%	135.3
	Zinc	26,599.2	68.1%	8,485.1
Middle Fork, North Fork, Main Stem Warm Springs Creek (MT41I006_100) (MT41I006_180)	Arsenic	472.8	58.7%	195.1
	Cadmium	14.3	61.9%	5.4
	Lead	102.5	31.6%	70.1
	Zinc	7,076.0	43.8%	3,976.7
Prickly Pear Creek (MT41I006_020) (MT41I006_030) (MT41I006_040) (MT41I006_050) (MT41I006_060)	Arsenic	9,497.9	58.5%	3,942.6
	Cadmium	652.1	73.8%	171.2
	Copper	14,200.1	58.0%	5,968.3
	Lead	6,627.9	68.6%	2,081.8
	Zinc	293,913.6	59.6%	118,623.5
Sevenmile Creek (MT41I006_160)	Arsenic	1,203.8	51.9%	578.7
	Copper	1,565.8	47.1%	828.0
	Lead	766.7	63.0%	283.8
Silver Creek (MT41I006_150)	Arsenic	2,752.5	64.6%	974.4
Spring Creek (MT41I006_080)	Arsenic	671.2	56.1%	294.6
	Cadmium	123.6	87.1%	15.9
	Copper	1,860.7	64.1%	668.0
	Lead	1,195.0	81.6%	219.8
	Zinc	74,792.8	80.7%	14,401.0
Tenmile Creek (MT41I006_141) (MT41I006_142) (MT41I006_143)	Arsenic	5,566.8	65.6%	1,912.6
	Cadmium	343.4	80.3%	67.6
	Copper	7,247.7	69.2%	2,232.4
	Lead	3,438.4	78.7%	734.1
	Zinc	96,844.7	54.9%	43,706.0

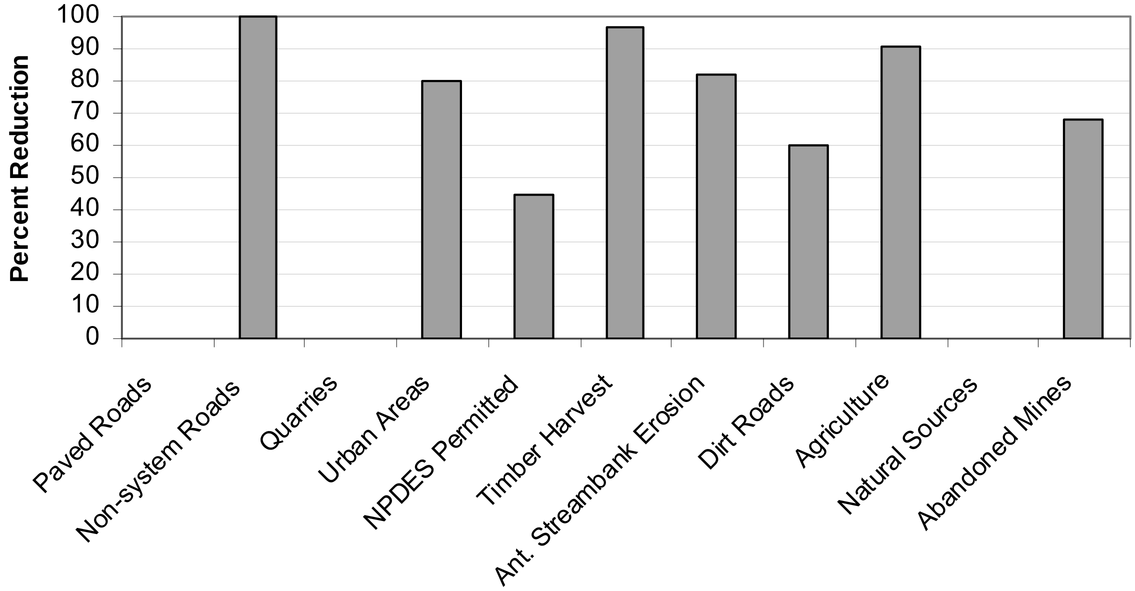


Figure 3-15. Percent Reductions by Source Category - Arsenic

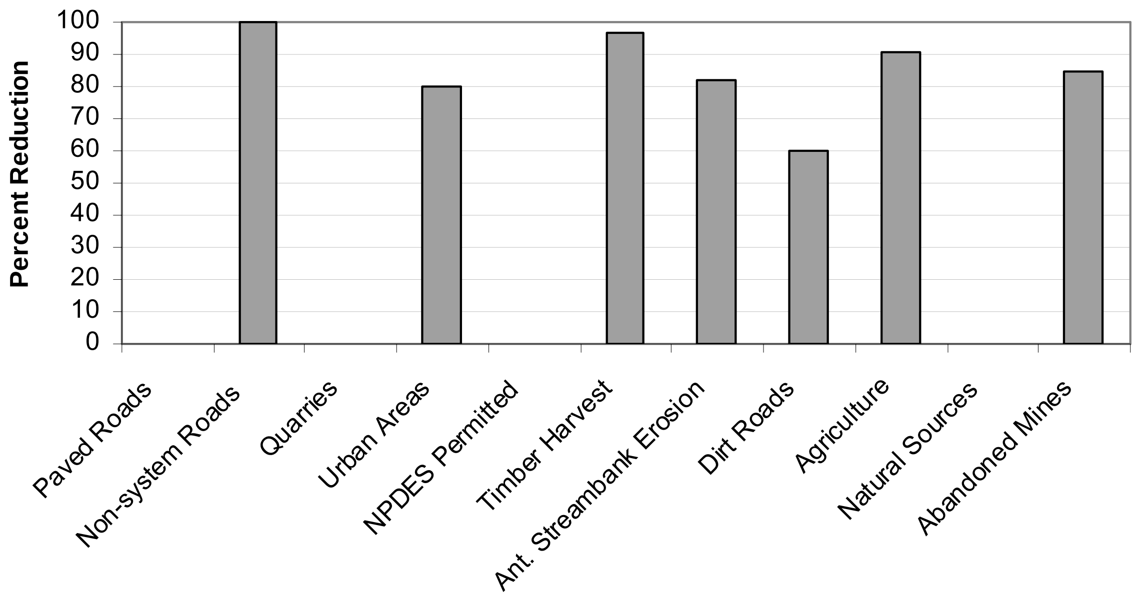


Figure 3-16. Percent Reductions by Source Category - Cadmium

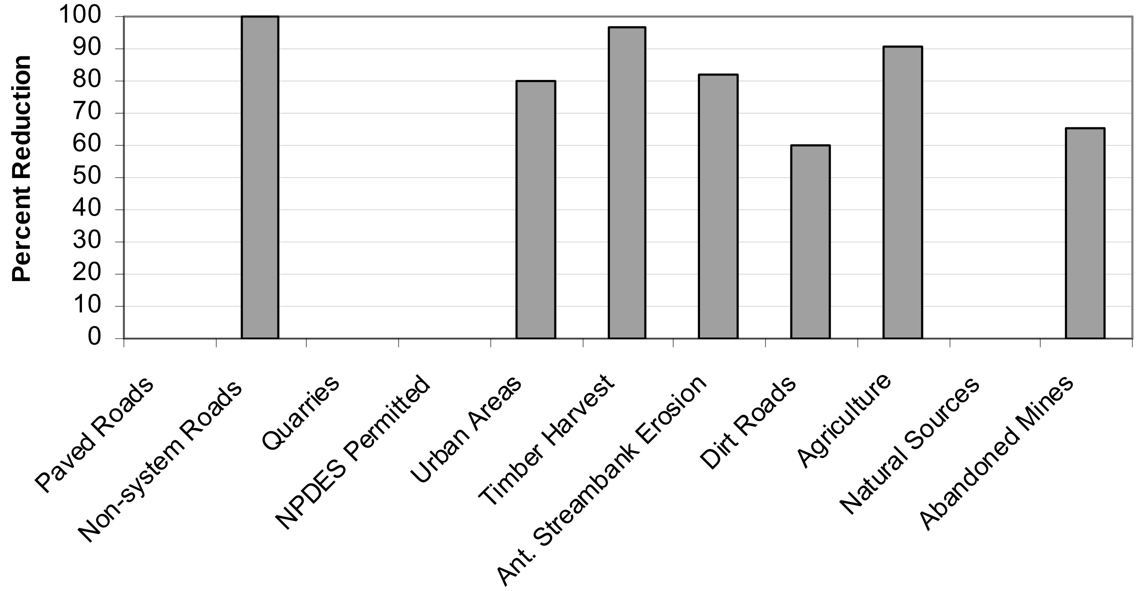


Figure 3-17. Percent Reductions by Source Category - Copper

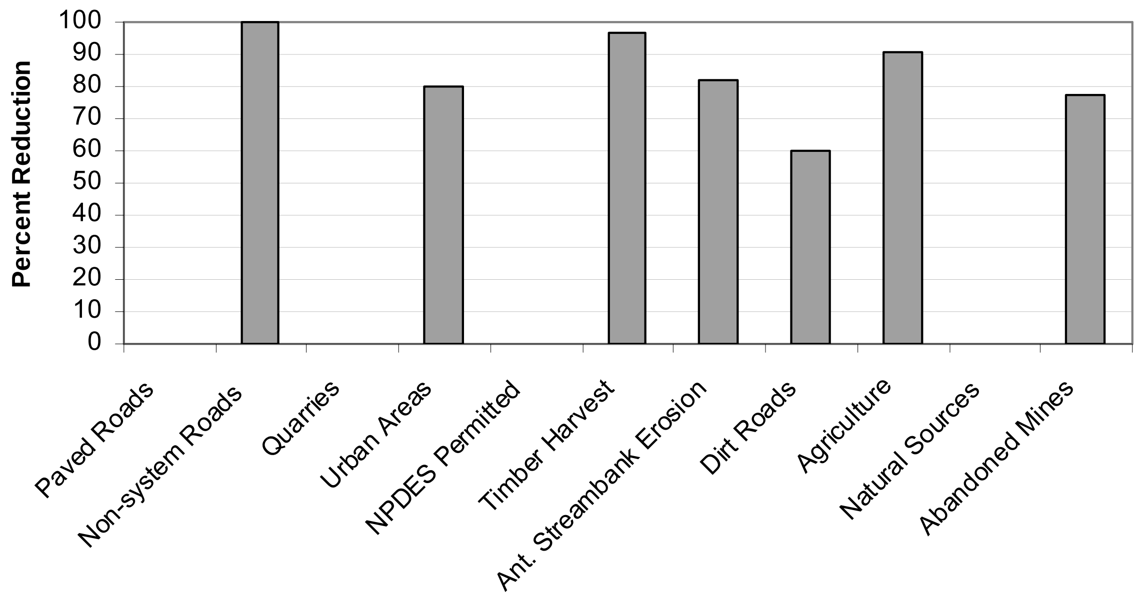


Figure 3-18. Percent Reductions by Source Category - Lead

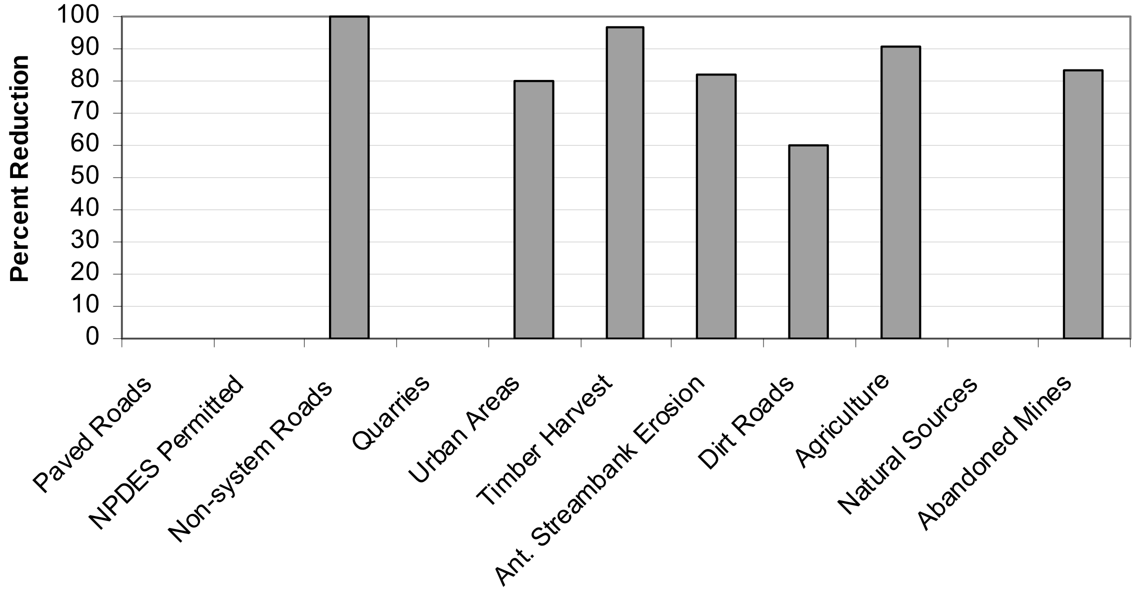


Figure 3-19. Percent Reductions by Source Category - Zinc

3.4 TEMPERATURE

The Problem:	Available data suggest that existing temperatures in Prickly Pear Creek are higher than natural stream temperatures. Increased stream temperatures can have negative effects to fish and aquatic life, potentially limiting reproduction and feeding habits, and potentially causing shifts in fish species composition from cold-water to warm-water fish.
Water Bodies of Concern:	Prickly Pear Creek
The Source:	Human-caused riparian degradation, flow alterations, and point source dischargers.
In-Stream Temperature Goals:	Attain and maintain the state's applicable numeric and narrative temperature water quality standards.
The Solution:	Improve riparian vegetation and increase stream flows.
Technical reports prepared in support of the metals overview presented in this section of Volume II include: • ***Appendix A*** *– Total Maximum Daily Load Summary* • ***Appendix G*** *– SSTEMP Temperature Modeling* • ***Appendix H*** *– Supplemental Monitoring and Assessment Strategy*	

3.4.1 Temperature Impairment and Water Bodies of Concern

Fish and aquatic life are adapted to live within a specific range of stream temperatures. When stream temperatures are increased, fish and aquatic life begin to show impairment, ranging from reduced reproduction to altered feeding habits (USEPA, 1976; Coutant, 1977; Cherry et al., 1977; Bell, 1986; Lee and Rinne, 1980). Prolonged periods of extremely warm temperatures can be fatal. Over several years, increased stream temperature ultimately leads to a shift from primarily coldwater species (i.e., salmonids) to warmwater fish species.

Based on the results presented in Volume I, temperature problems currently exist in the water bodies listed below and shown in Figure 3-20.

- Prickly Pear Creek (MT41I006_040) – Confluence with Lump Gulch to the Wylie Drive Bridge (10.2 miles).
- Prickly Pear Creek (MT41I006_030) – Wylie Drive to Helena Wastewater Treatment Plant discharge (4.3 miles).
- Prickly Pear Creek (MT41I006_020) – Helena Wastewater Treatment Plan to the mouth (5.9 miles).

Elevated stream temperatures have been documented in these water bodies. Volume I provides details regarding the degree of impairment and how the impairments are manifested. In general, impairments are due to riparian degradation and flow alterations.

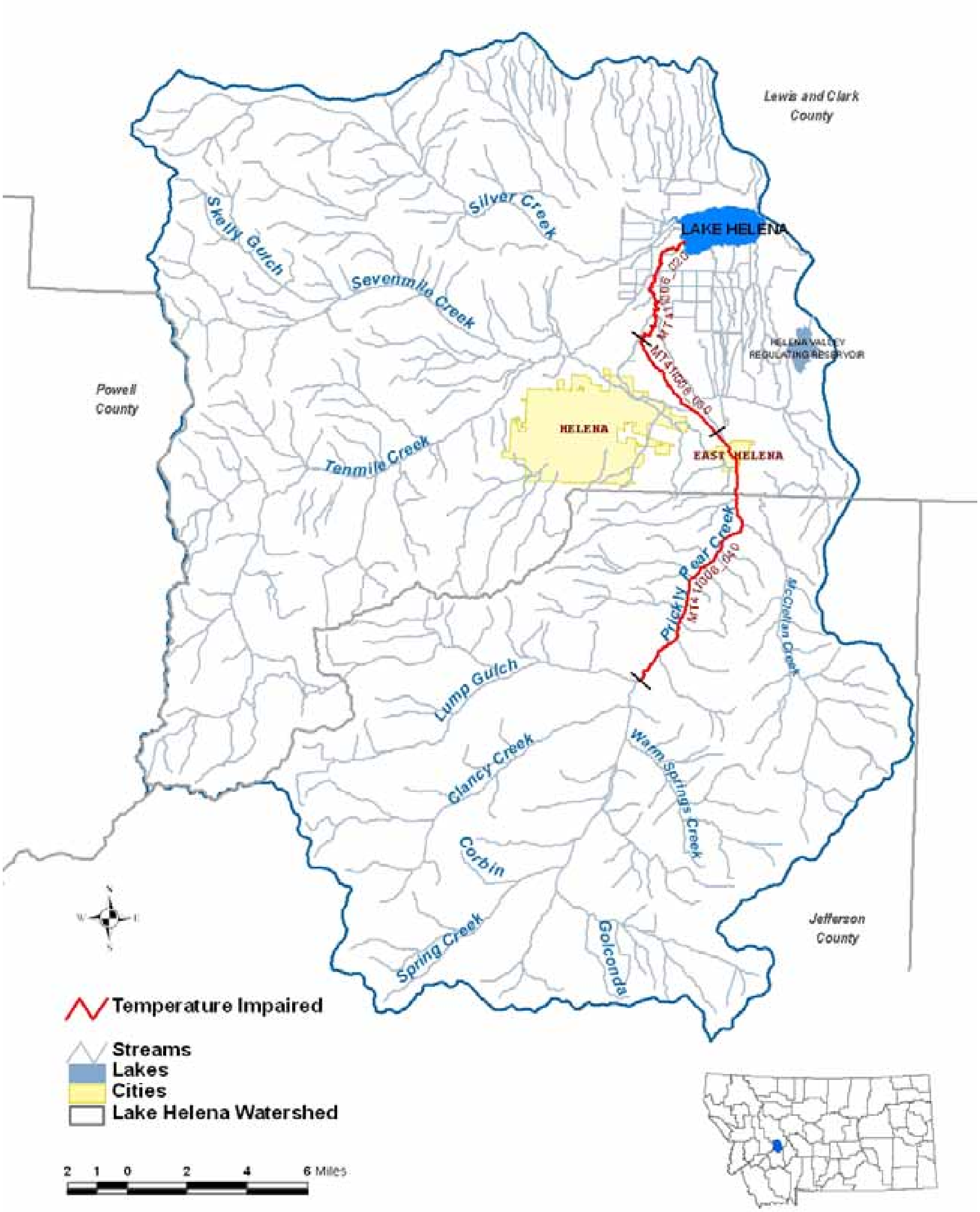


Figure 3-20. Streams in the Lake Helena watershed impaired by temperature.

3.4.2 Sources of Temperature Impairment in Prickly Pear Creek

Anthropogenic sources of temperature change in Prickly Pear Creek include flow alterations, riparian degradation, and point sources. The SSTEMP model was used to estimate the impacts from each of these sources during a critical summer, low flow event (see Appendix G for details regarding sources and the SSTEMP model). In segment MT41I006_040, riparian degradation increases the average daily stream temperature by 0.90 degrees Fahrenheit. Flow alterations increase the stream temperature by 1.8 degrees Fahrenheit, and point sources have a negligible effect. With the model uncertainty, anthropogenic sources increase the average daily stream temperature in segment MT41I006_040 by 2.7 $\pm$ 0.5 degrees Fahrenheit.

Downstream of the Wylie Drive Bridge, Prickly Pear Creek is completely dewatered during low flow summer months (segment MT41I006_030). Therefore, the SSTEMP model could not be used. Near the Helena WWTP outfall, flow returns to Prickly Pear Creek via groundwater recharge, point sources, and irrigation returns. This then makes up the majority of the summer flow in segment MT41I006_020 (Helena WWTP to the mouth). Given the complications associated with upstream flow alterations, it is not possible at this time to evaluate the affects of riparian degradation or dewatering on temperature in segment MT41I006_020. However, the riparian survey suggests that current conditions (i.e., degraded riparian vegetation) are most likely causing some level of temperature impairment.

3.4.3 In-Stream Temperature Goals

The ultimate goal of this plan and associated TMDLs is to attain and maintain water quality standards. Montana’s water quality standards for temperature are numeric. However, the definition of ‘naturally occurring’ water temperature within the state standard must be interpreted to derive measurable water quality goals.

Since the success of this plan and associated TMDLs will be evaluated five years after it is approved (i.e., 2011 assuming approval in 2006), flexibility must be provided herein for the interpretation of ‘naturally occurring’ water temperature in Prickly Pear Creek. The water quality standards and indicators presented in Table 3-11 are proposed as end-point water quality goals (i.e., targets) for temperature, in recognition of the fact that they may need to be changed in the future as new information becomes available and/or DEQ implements a new methodology for interpreting ‘naturally occurring’ water temperature.

The suite of indicators used to evaluate compliance with Montana’s temperature standards in the future should be selected based on the best data and information available, and/or the current DEQ methodology available, at that time.

Table 3-11. Proposed temperature water quality endpoints.

Water Quality Indicator	State Water Quality Standard	
Water Temperature: A change in temperature due to anthropogenic sources, or variation from a reference condition.	**B-1 Class Waters:** $\leq 1^{\circ}$ F when water temperature is $< 67^{\circ}$ F $\leq 0.5^{\circ}$ F when water temperature is $> 67^{\circ}$ F **I Class Waters:** No increase in naturally occurring water temperature.	
Water Quality Indicator	**Rationale for Selection of this Indicator**	**Proposed Criteria**
Percent Shade	Shading provided by riparian vegetation is a significant factor for reducing thermal energy input to Prickly Pear Creek. Riparian vegetation can also influence channel form and the amount of surface area exposed to solar heating.	60 Percent
Fish Population Metrics	The presence of cold-water fish can be an indication of the temperature suitability of a stream, when the waterbody is not limited by other water quality or habitat constraints.	MFISH rating of “best” or “substantial”
Stream Flow	Because water has a high specific heat capacity, larger volumes of water are subject to fewer fluctuations in temperature. By increasing flow, the stream will be more resistant to temperature increases.	Maintain MFWP’s recommended year round aquatic life survival flow targets: 8 to 22 cfs for Prickly Pear Creek from the headwaters to East Helena, 14 to 30 cfs from East Helena to Lake Helena.

3.4.4 The Solution

The solution to the temperature problem in Prickly Pear Creek is to reduce the impacts from anthropogenic temperature sources. Using the temperature targets, the necessary temperature reduction in segment MT41I006_040 (Lump Gulch to Wylie Drive Bridge) is 2.2 degrees Fahrenheit. To meet this target, it is proposed that riparian vegetation should be restored to its maximum potential along all of segment MT41I006_040. This would result in a 0.9 degree Fahrenheit decrease in stream temperature. It is also recommended that flows should be augmented by a minimum of 8.5 cubic feet per second. This would result in a 1.3 degree Fahrenheit decrease in stream temperature. It is recognized here that neither Montana DEQ nor USEPA has authority to regulate non-point sources (i.e., riparian vegetation or flow). Therefore, implementation of this TMDL will be voluntary, with watershed stakeholders ultimately deciding the restoration strategy. All TMDL elements for this segment are included in Appendix A.

At this time, temperature TMDLs could not be calculated for Prickly Pear Creek downstream of Wylie Drive. During critical summer low flow months, the stream is dry between the Wylie Drive Bridge and the Helena wastewater treatment plant outfall (segment MT41I006_030) due to flow alterations. Flows in segment MT41I006_020 primarily consist of groundwater recharge and irrigation returns, and therefore currently do not reflect any upstream temperature impairments or improvements. Sources in both segments MT41I006_030 and MT41I006_020 will be reevaluated after implementation of the TMDL for segment MT41I006_040, and TMDLs, if necessary, will be calculated at that time. Additionally, temperature monitoring is proposed for the Helena and East Helena WWTP outfalls to evaluate the temperature impacts from these two point sources (see Appendix H).

4.0 CONCEPTUAL IMPLEMENTATION STRATEGY

The Framework Water Quality Restoration Plan and TMDLs established a starting point for addressing a host of water quality problems and pollution sources throughout a very large geographic area. The plan identifies the desired water quality endpoints, and quantifies the amount of pollutant reductions, by source, that will be required to restore water quality and beneficial water uses. It also defines, in general terms, a diverse assortment of restoration actions and management approaches. We acknowledge that implementing this plan, and achieving the desired water quality improvements, will not be easy.

Permanent solutions to the many and varied water quality issues will only be realized through teamwork, commitment, and ongoing planning by public entities and private citizens. The proposed phased nature of the plan, and the remaining data gaps and uncertainty, will require a mechanism for continued oversight and coordination, and a monitoring program and feedback loop. Ultimately, the success of the Lake Helena watershed water quality restoration plan will be determined by the local community and their level of support and commitment towards continuing the implementation process over the coming decades.

We acknowledge that the real work lies ahead, and that it won't happen spontaneously. Some proposed action items for ensuring the success of the Lake Helena watershed plan are described in the following paragraphs.

4.1 PUBLIC EDUCATION AND OUTREACH

The State of Montana has a variety of groups involved in watershed restoration work. It has been clearly experienced and documented that implementation of water quality restoration activities take an extensive amount of time in terms of educating the public on the local problems and to develop stakeholder buy-in to the various restoration activities that need to occur. The need for public education and outreach is the same for the Lake Helena Planning Area. Until a higher level of public understanding and support is achieved, it will be difficult to successfully implement this plan.

In order to facilitate transition from the planning steps taken by the State and Federal agencies in Phase II of the Lake Helena process to development of a locally driven implementation effort, EPA and MDEQ propose to schedule and conduct a series of stakeholder meetings as a starting point. The purpose of the meetings would be to review the technical basis for the plan in layman's terms, and to elicit cooperation and build support for pursuing the next steps. Targeted audiences would be local watershed groups, relevant local, state, and federal agencies, conservation districts, municipalities, landowners, and the general public. An effort will also be made to identify potential stakeholders that may have been overlooked. The public meetings may be geographically based so that residents of each sub-basin (e.g., Prickly Pear Creek watershed) can have focused discussions on their primary areas of interest. The timeframe for conducting these meetings is proposed to run from January through May 2006.

At the conclusion of these meetings, EPA and MDEQ envision a strengthening of efforts that have been conducted to date and the establishment of a key set of stakeholders willing to work to implement voluntary point source and non-point source activities. MDEQ's Watershed Restoration Implementation Section would be available to provide continued assistance to the local participants in pursuing these activities.

4.2 Coordinated Watershed-Scale Approach

EPA and MDEQ feel strongly that a comprehensive watershed based approach is needed to successfully implement the Lake Helena watershed plan. The basic premise for a watershed approach is that many water quality problems are best solved at the watershed level rather than at the individual water body or point source discharger level. This is particularly true in the Lake Helena watershed where more localized water quality impairments in the Prickly Pear, Tenmile, and Silver Creek sub-basins also contribute to downstream problems in Lake Helena, and quite likely Hauser Reservoir and the Missouri River. By simultaneously addressing all pollution sources and potential future sources on a watershed-wide basis, we can set the stage for comprehensive, equitable and lasting solutions.

This plan addresses a variety of water quality issues associated with the following four categories of pollutants: nutrients, metals, sediment, and temperature. While each of these categories have been addressed separately in the main body of this document, and each water body/pollutant combination is addressed separately in the TMDLs presented in Appendix A, it is recognized that there is a great deal of commonality in the solutions that may be applied to restore water quality. For example, lack of riparian vegetation reduces the amount of shade and thereby increases stream temperatures. The solution for reducing stream temperatures is to restore the riparian vegetation community. Since healthy riparian vegetation communities also buffer stream banks against erosion and filter sediments, this solution addresses metals, sediment, and nutrient problems as well as temperature problems. As another example, since metals and some forms of nutrients are often adsorbed onto sediment, almost all of the recommended measures to reduce sediment loading will also reduce metals and nutrient loading.

Within a comprehensive watershed framework, we remain open to using the major sub-basins as a focal point for implementation of various restoration activities. For example, the Upper and Lower Tenmile Watershed Groups, and the newly formed Prickly Pear Watershed Group, may be in the best position to direct implementation activities within those respective sub-basins. These activities could include weed control, oversight of abandoned mine cleanup activities, stream bank stabilization and erosion control measures, application of agricultural best management practices, landowner education efforts, and others. However, we feel that some sort of mechanism will be required to coordinate all of the various activities on a watershed scale, even though many may be pursued on a localized level. A conceptual framework is discussed in the next section.

4.3 Institutional Framework

There are 11 unique sources that will need to be addressed, and 24 watershed stakeholder groups/entities that will likely need to participate to effectively implement this plan.

The Lake Helena watershed water quality restoration plan includes recommendations for numerous point and non-point source pollution control measures involving many different entities. An effective organizational framework is needed to facilitate planning, funding, implementation, and coordination of individual restoration measures as well as the watershed-wide plan as a whole.

Since neither Section 303(d) of the Clean Water Act nor the Montana Water Quality Act creates any implementing authority for TMDLs, implementation will rely on a combination of regulatory and non-regulatory means that will ideally be lead by watershed stakeholders. The obvious starting point for the development of an institutional framework to implement this plan would be those stakeholders who have authority over, or association with, the most significant current and future pollutant sources. Table 4-1 provides a list of the top five most important sources for each of the pollutants considered in this analysis along with the watershed stakeholders. All told, there are 11 unique sources that will need to be addressed, and 24 watershed stakeholder groups/entities that will likely need to participate to effectively implement this plan. The 11 unique sources include: municipal wastewater treatment facilities, septic systems, the Helena Valley Irrigation System, agriculture, urban areas, dirt roads, timber harvest, streambank erosion, abandoned mines, degraded riparian vegetation (i.e., lack of shade), and dewatering. The associated watershed stakeholders that will need to part of the solution include (in no particular order of importance):

Watershed Stakeholders

MT. Department of Environmental Quality
- Water Quality Protection Program
- TMDL Program
- Subdivision Review Program
- Permitting Program

U.S. Environmental Protection Agency
- Superfund Program
- TMDL Program
- Non-point Source Program

City of Helena
City of East Helena
Helena Valley Irrigation District
U.S. Bureau of Reclamation
U.S. Bureau of Land Management
Lewis & Clark County
- Board
- Commission
- Public Works/Roads
- Water Quality Protection District
- Conservation District

Jefferson County
- Board
- Commission
- Public Works/Roads
- Conservation District

Helena National Forest
Natural Resource Conservation Service
MT Dept. of Natural Resources and Conservation
Private Landowners

MDEQ has responsibility for overseeing the implementation of TMDLs on a statewide basis. At the same time, MDEQ does not have the regulatory or statutory authority or funding mechanisms to implement the many and varied solutions to address each of the primary sources of water quality degradation in the watershed. This will have to be conducted at the local level. It is proposed that MDEQ and EPA work with the watershed stakeholders to establish a Lake Helena Watershed Committee that would oversee and coordinate the implementation of the Lake Helena water quality restoration plan. Representation on the committee would include all watershed stakeholders, including local watershed groups, municipal and county governments, conservation districts, state natural resource agencies, the federal land management agencies, local conservation organizations, various businesses and industry, and citizens at large. Individual work groups would need to be established within the committee to focus on a series of subtasks of the restoration plan, for example public education, point source controls, non-point source controls, monitoring and data gaps, flow enhancement, and others. Another tier of the organizational structure could provide implementation oversight for activities that may occur within each of the three major sub-basins. A separate work group could focus on securing and coordinating overall project funding.

The committee would create a work plan and budget, and secure commitments from participants for various implementation measures. These could take the form of activities already being pursued by the separate entities represented within the Lake Helena Watershed Committee. Some examples are septic system maintenance education by Lewis and Clark County, erosion control projects by the local watershed groups, forest travel management planning by the Helena National Forest, planned infrastructure improvements by the City of Helena, and others. Other needed measures can be planned well in advance, with implementation and funding details worked out by the committee.
Incentives for participation in the Lake Helena Watershed Committee would come in part from funding opportunities that are available for TMDL implementation activities, for example the annual EPA Section 319 grants. Another incentive would come from grant leveraging opportunities where one funding source could be used as a matching contribution towards another grant. A third incentive relates to equitability issues, where the work and responsibility of attaining the necessary pollutant reductions is shared by multiple parties. Perhaps the greatest benefit to participants will be the actual water quality improvements that can only be realized through teamwork and a unified approach to watershed-wide water quality improvement.

Collectively, a broad base of stakeholders operating within this type of framework could optimize implementation efforts by pooling resources and expertise, and by improving communication and coordination among all parties.

Table 4-1. Top five pollutant sources in the Lake Helena watershed and associated watershed stakeholders.

NOTE: This is a draft table. MDEQ and EPA are specifically seeking comments from the public regarding the list of stakeholders provided herein.

Nutrients		Sediment		Metals		Temperature	
Sources	**Stakeholders**	**Sources**	**Stakeholders**	**Sources**	**Stakeholders**	**Sources**	**Stakeholders**
Municipal Wastewater Treatment Facilities	City of Helena, City of East Helena, MDEQ Wastewater Permitting Program, MDEQ State Revolving Fund Program	Dirt Roads	Helena National Forest, Lewis and Clark and Jefferson County Governments, MDEQ Subdivision Review Program, Private Landowners	Abandoned Mines	EPA Superfund Program, MDEQ Abandoned Mine Program	Degraded Riparian Vegetation (i.e., lack of shade)	Private Landowners, Conservation Districts, LCWQPD
Septic Systems	MDEQ Subdivision Review Program, Lewis & Clark and Jefferson County Boards and Commissions, City of Helena, City of East Helena, LCWQPD, Private Landowners	Agriculture	Conservation Districts, NRCS, Helena Valley Irrigation District, Bureau of Reclamation, Private Landowners	Agriculture	Conservation Districts, Natural Resource Conservation Service, Helena Valley Irrigation District, Bureau of Reclamation, Private Landowners	Dewatering	Helena Valley Irrigation District, Bureau of Reclamation, Conservation Districts, NRCS, EPA Superfund Program, City of Helena, Private Landowners
Helena Valley Irrigation System	Helena Valley Irrigation District, Bureau of Reclamation, Conservation Districts, NRCS, EPA Superfund Program, City of Helena, Private Landowners	Timber Harvest	Helena National Forest, Department of Natural Resources and Conservation, Bureau of Land Management, Private Landowners	Dirt Roads	Helena National Forest, Lewis and Clark and Jefferson County Governments, MDEQ Subdivision Section, Private Landowners	NA	
Agriculture	Conservation Districts, Natural Resource Conservation Service, Helena Valley Irrigation District, Bureau of Reclamation, Private Landowners	Streambank Erosion	Private Landowners, Conservation Districts, LCWQPD	Streambank Erosion	Private Landowners, Conservation Districts, LCWQPD	NA	
Urban Areas	MDEQ Storm water Permitting Program, MDEQ Subdivision Review Program, Lewis & Clark and Jefferson County Boards and Commissions, City of Helena, City of East Helena, LCWQPD, Private Landowners	Abandoned Mines	EPA Superfund Program, MDEQ Abandoned Mine Program	Timber Harvest	Helena National Forest, Department of Natural Resources and Conservation, Bureau of Land Management, Private Landowners	NA	

4.4 Adaptive Management

Conclusions and recommendations contained in the Lake Helena restoration plan are based on the best information and data that are currently available. Nonetheless, we acknowledge that uncertainties or data gaps exist with regard to some of the proposed water quality targets, TMDLs, and pollutant allocations, especially for Lake Helena. Other unknowns are present as well, such as the ability of the proposed restoration measures to completely attain the needed pollutant reductions. The proposed adaptive management approach will allow us to move forward with water quality improvement activities at the same time that additional data gathering occurs. These data will then be used to confirm or adjust some of the plan's technical assumptions, to fill remaining data limitations (e.g. Lake Helena), and to evaluate the effectiveness of restoration measures on an individual and collective basis.

4.5 Measuring Success

Focused monitoring efforts will be required to fulfill three primary objectives:

- Obtain additional data to address information gaps and uncertainty in the current analysis (data gaps monitoring and assessment).
- Ensure that identified management actions are undertaken (implementation monitoring)
- Ensure that management actions are having the desired effect (effectiveness monitoring)

Proposed basic elements of a monitoring strategy to meet these three objectives are described below, with expanded discussions provided in Appendix H of this report. During the implementation phase, a more detailed monitoring and analysis plan will need to be prepared.

4.5.1 Data Gaps Monitoring

Monitoring to fill current data gaps is the highest priority because these data are needed to move forward with specific restoration strategies. For example, only interim nutrient targets have been established for the streams in the Lake Helena watershed due to uncertainty associated with the technical or economic feasibility of attaining the proposed values. Similarly, no nutrient concentration targets are presented for Lake Helena due to limited historic and recent water quality data and an incomplete understanding of the hydrologic relationship between Lake Helena and Hauser Reservoir. A lack of data also resulted in an incomplete understanding of several of the metals impairments. Additional monitoring is therefore needed to address these data gaps and will consist of the following:

- Watershed hydrology and groundwater/surface water studies to better understand water management, groundwater, and water quality interactions within the Helena Valley.
- An in-stream nutrient target setting and source assessment study to develop a better understanding of the relationship between nutrient concentrations and beneficial use impairment in lower Prickly Pear Creek, including the compilation of sufficient data for a more refined modeling analysis.
- A study of Lake Helena and Hauser Reservoir nutrient dynamics to better assess conditions within these two waterbodies, and to refine the nutrient loading/lake response model.
- Metals monitoring in segments that had limited data to ascertain the level of impairment with confidence.
- Temperature monitoring to better understand the impact from point source discharges and flow alterations.
- A study to collect additional data for model calibration and refinement.

EPA and MDEQ propose to take the lead in performing these activities assuming adequate budgets and resources. Additional details are provided in Appendix H of this report.

4.5.2 Implementation Monitoring

The purpose of implementation monitoring is to document whether or not management practices were applied as designed. Objectives of an implementation monitoring program include:

- Measuring, documenting, and reporting the watershed-wide extent of BMP implementation and other restoration measures, including point source controls.
- Evaluating the general effectiveness of BMPs as applied operationally in the field.
- Determining the need and direction of BMP education and outreach programs.

Implementation monitoring consists of detailed visual monitoring of BMPs, with emphasis placed on determining if they were implemented or installed in accordance with approved design criteria. This type of information will provide the Lake Helena Watershed Committee with an inventory of where BMPs have been applied and their effectiveness. The various watershed stakeholders should take the lead in performing the implementation monitoring as it is likely to vary by each type of BMP. For example, the USFS has the most expertise in assessing forestry BMPs whereas City of Helena personnel are likely most familiar with urban storm water controls.

4.5.3 Effectiveness Monitoring

Montana Code Annotated 75-5-703(9)(c) provides a provision requiring that MDEQ evaluate all TMDLs five years after they have been completed and approved. A formal review of the Lake Helena TMDL will therefore occur in 2011/2012 and will use the water quality endpoints identified for each pollutant (and/or the endpoints that best represent interpretations of the water quality standards in affect at that time) to assess overall progress toward meeting water quality restoration goals. This effort will include a combination of water quality and biological monitoring and habitat assessment aimed at determining the effectiveness of restoration activities. Although this assessment can be made based on data collected by MDEQ only in year five, a much more thorough assessment will be possible if additional data are collected during the intervening years. Due to MDEQ resource constraints, these additional data would need to be collected by watershed stakeholders.

Nutrient effectiveness monitoring in Prickly Pear Creek should consist of monthly sampling of general water quality in 2011, as well as targeted collection of attached algae and dissolved oxygen data during the critical summer months. One purpose of this monitoring is to assess the degree to which the implemented point and non-point source controls have reduced ambient nutrient concentrations compared to the available historical data. Another purpose is to determine whether in-stream nutrient reductions have lead to corresponding decreases in algal standing crops and the magnitude of dissolved oxygen sags. Nutrient effectiveness monitoring should also be conducted in Lake Helena and Hauser Reservoir in 2011 using the nutrient/limnologic parameters that were previously described in Section 2.3 above.

Sediment water quality endpoints should be assessed on a maximum interval of five years in order to judge the degree of target acquisition. However, biannual data collection at fixed plots is more applicable, and should be conducted following the implementation of restoration activities, with subsequent data collection on every fifth year. Three years of data collection every five years will provide a basis for trend analysis, and determination of the level of benefits associated with restoration activities. The exception to the biannual data collection strategy is suspended sediment sampling, which should occur on a more frequent basis (quarterly, if resources can support this level of intensity).

Temperature monitoring of Prickly Pear Creek segments should be conducted seasonally for a minimum of three years following the implementation of control measures. Montana DEQ protocols should be used for all sampling events, and the data should be recorded and submitted to the MDEQ. The effectiveness monitoring strategy for temperature should include in-stream temperature and stream flow monitoring and the collection of weather data to determine representativeness of the results. Records from the nearest NOAA weather station should be used to monitor local weather for the area of interest.

Effectiveness monitoring for metals should consist of sampling the metals of concern, along with hardness, pH, and instantaneous flow. Monthly sampling in 2011 is recommended at the mouth of every listed segment throughout the Lake Helena watershed. Additional sampling during runoff events (from snowmelt and summer storms) is also recommended. The data will be evaluated for the presence and spatial persistence of any numeric criteria violations.

4.5.4 Future Sources

> **Future Sources**
>
> *Although it may be possible to attain water quality standards by addressing sources that exist today, it will not be possible to maintain water quality standards unless decisions about potential future sources are made in consideration of water quality.*

Much of this document, and associated TMDLs in Appendix A, focuses on addressing current pollutant sources in an effort to <u>attain</u> water quality standards. It will be equally important to address future pollutant sources to <u>maintain</u> water quality standards. For example, in Section 3.2.1 it was noted that TN and TP loads are predicted to increase by 43 and 78 percent, respectively, in the foreseeable future if population growth continues at current rates. Nutrient loading is unequivocally linked to population growth. The two cannot be separated. According to EPA's "Onsite Wastewater Treatment Systems Manual" (2002), each person contributes 4.8 to 13.7 pounds of nitrogen and 0.8 to 1.6 pounds of phosphorus per year. Municipal wastewater and septic systems are currently among the top three most important sources of TN and TP. Since municipal wastewater treatment and/or septic systems are the conventional means for controlling the discharge of these pollutants from domestic wastewater, these two sources will become even more important nutrient sources in the future as the population increases. Each addition to the population within the watershed will produce an incremental increase in nutrient loading. Given that septic systems do not effectively control TN loading, and there are technical and economic constraints associated with attaining the maximum level of treatment for both TN and TP in municipal wastewater treatment facilities, it is inevitable that nutrient loading to the waters in the Lake Helena Watershed will increase in the future as the population grows. <u>It is imperative, therefore, that future decisions regarding land use changes be made with full knowledge and understanding of future water quality implications. It is also imperative that cumulative affects are considered and all actions are evaluated at the watershed scale.</u>

Although the example provided above focused on future nutrient sources, the same concept holds true for the other pollutants considered in this analysis (e.g., future forest harvest, future unpaved roads, new mining facilities, etc. may all result in increased pollutant loads).

A number of tools have been prepared to support the technical analyses presented in this document, will be prepared in the future as part of future phases of this effort, and/or already exist that could/should be used to consider the water quality implications associated with future land use decisions. For example, a watershed-scale nutrient loading model (GWLF) has been developed as part of this project (see Appendix C). While this is a relatively simplistic tool, it has been useful and could be useful in the future to evaluate the water quality impacts of future land use changes before decisions are made at the state, county or local level to proceed with them. Further, as briefly described in Section 3.2.3.2 and Appendix H, a more detailed model will be developed for Prickly Pear Creek that would allow decision makers to specifically simulate future land use changes and determine what the water quality consequences may be. For example, this modeling tool (or other similar tool) could be used to evaluate the net affect of extending sewer service to previously un-sewered areas. A question that could be answered in this hypothetical example might be: *By how much, if at all, are TP and TN loads reduced to Prickly Pear Creek and/or Lake Helena by extending the sewer service and what is the cost/benefit ratio?*

5.0 SUMMARY OF PUBLIC INVOLVEMENT ACTIVITIES

5.1 INTRODUCTION

EPA and Montana DEQ recognize the critical importance of public and stakeholder involvement in the Lake Helena water quality restoration planning process. The agencies are sensitive to the fact that the basin's water quality problems stem from predominately diffuse (or non-point) pollution sources whose resolution will require cooperative, largely voluntary approaches. We understand that landowners, agricultural producers, private business owners, the federal land management agencies, and other government and municipal entities cannot be expected to actively participate in the water quality restoration process if they are not kept informed as the plan is developed, and if their input is not solicited and valued. In recognition of these needs, staff of the Montana EPA office and Montana DEQ, together with Lake Helena project contractors and local watershed group coordinators, have made a concerted effort to provide opportunities for public dialogue and input throughout the Lake Helena water quality restoration planning process.

It should be noted that this document is a public review draft that is currently undergoing review by the public. It is expected, and hoped, that numerous public comments will be received. The final version of this document will include a summary of all comments received and may be revised in response to public comment. This section of the document summarizes only the public involvement activities that have occurred to date.

The following is a summary of activities conducted between 2003 and 2005 to keep local watershed residents and agency representatives informed of progress in developing Volumes I and II, to provide opportunities for input and dialogue, and to address coordination issues.

5.2 LOCAL WATERSHED GROUP MEETINGS AND WORKSHOPS

Project staff attended regular meetings of the Upper Tenmile Watershed Group, the Lower Tenmile Watershed Group and, more recently, the Prickly Pear Watershed Group to provide updates on the Lake Helena project, to answer questions and participate in discussions, and to keep appraised of activities with potential relevance to the Lake Helena project.

Staff attended Lower Tenmile Watershed Group meetings on January 15, February 11, March 18, May 20, July 15, October 16, and November 20, 2003; on February 19, March 25, and April 15, 2004; and on February 17, April 21, and September 15, 2005. Focused presentations on the Lake Helena project were given at the meetings on January 15, 2003 and February 17, 2005. A lapse in attendance of the meetings in mid-2004 was due to a temporary slow down in the project and a lack of reportable items. Lake Helena project staff participated in volunteer riparian planting activities along Tenmile Creek in May 2003 and 2004.

Upper Tenmile Watershed Group meetings were attended on February 27, March 27, May 29, July 31, and September 25, 2003; and on February 26 and March 25, 2004. A focused presentation on the Lake Helena project was given at the meeting on February 27, 2003.

A Prickly Pear Watershed Group meeting was attended on May 3, 2005. A presentation on water quality issues in the Prickly Pear watershed was given at a Prickly Pear Know Your Watershed Workshop on April 24, 2004. This workshop set the stage for creation of the Prickly Pear Watershed Group.

5.3 Conservation District Meetings

Lake Helena project staff attended meetings of the Lewis and Clark County Conservation District on March 13, June 19 and August 14, 2003; on January 8 and October 14, 2004, and on January 19 and March 10, 2005; and meetings of the Jefferson Valley Conservation District on February 18, April 15, July 15, October 21, and November 18, 2003 to provide updates on the Lake Helena project and to answer questions.

5.4 Agency Partnerships and Consultation

Several state and federal agencies have been closely involved as cooperators in the Lake Helena water quality restoration project. Staff of the Helena National Forest Supervisor's Office assisted extensively with field monitoring and assessment activities in summer 2003, and have continued to be closely involved with design of pollution source assessment approaches and water quality target setting. Montana Fish, Wildlife and Parks staff assisted with the project through the provision of data, and by collecting fish tissue from area streams for mercury analysis. A host of local, state and federal agencies were contacted in early 2003 as part of an extensive data gathering effort and graciously provided access to their reference libraries and data pertaining to water quality and land management activities in the Lake Helena watershed. The Lewis and Clark County Water Quality Protection District staff person who serves as coordinator for the Lower Tenmile and Prickly Pear Watershed Groups has assisted the Lake Helena project team in the gathering of data, disseminating information to the public, and arranging meetings.

The Montana Department of Transportation convened an inter-agency and public group in 2003 to address coordination issues associated with plans to pave the Marysville Road. Lake Helena project staff participated in meetings of this group on a number of occasions because of potential relevance to the Silver Creek TMDLs and restoration planning process. Meetings of the Marysville Road Users' Group were attended in February, March, April, August, and October 2003; and in February 2004. A focused presentation on the Lake Helena project was given at a public hearing on the Marysville Road reconstruction plan at the Trinity School (Canyon Creek) on March 27, 2003.

Lake Helena project staff attended scoping meetings hosted by the Bureau of Reclamation on March 17, 2004 regarding renewal of water leases for the Helena Valley Irrigation District and City of Helena from the Canyon Ferry/Helena Valley Regulating Reservoir distribution system. Lake Helena project staff followed up the meeting by submitting written comments pertaining to the Lake Helena water quality restoration plan and relationships to the leasing proposal.

EPA project staff attended a meeting of the Lewis and Clark County Water Quality Protection District board of directors on February 22, 2005 to make a presentation on the Lake Helena project, to answer questions, and to discuss local coordination issues. These discussions were continued at additional meetings Helena city and county staff in April and October 2005.

Project staff worked closely with Helena National Forest staff on sediment source assessment activities and allocations. Additional meetings were held with Lewis and Clark County Water Quality Protection District and planning staff, the City of Helena Public Works Department, and East Helena municipal government regarding municipal wastewater, urban development and population growth, and conceptual TMDL implementation strategies..

Additional meetings focusing on metals TMDL coordination issues were held with the Bureau of Land Management, MDEQ Abandoned Mine Cleanup Bureau, and the EPA Superfund Program and their contractors.

5.5 Lake Helena Technical Advisory Committee

The Lake Helena project team organized and convened a meeting of a technical advisory committee on May 15, 2003 to create a sounding board for technical aspects of the Lake Helena project. The first meeting focused on data gaps, development of a monitoring plan, and selection of candidate least-impaired reference streams for use in impairment decisions. A second meeting of the group was held on March 9, 2005 with a purpose of reviewing progress to date and discussing the rationale behind the preliminary water quality restoration targets for sediment, nutrients, metals, temperature, and salinity. The committee met for a third time on September 13, 2005 to review the results of the completed pollution source assessment work, and to discuss the TMDL allocation process. The technical committee membership includes 16 representatives including all relevant local, state and federal agencies, as well as the Lower Tenmile and Upper Tenmile watershed Group facilitators.

5.6 Lake Helena Policy Advisory Committee

The Lake Helena project team organized and convened a meeting of a policy advisory committee on March 10, 2004 to begin a dialogue pertaining to policy planning and implementation aspects of the Lake Helena project. Project staff briefed meeting participants on the progress to date, including development of the preliminary water quality impairment status review, results of a preliminary pollution source assessment, a schedule of future activities, and anticipated population growth related challenges. A second meeting was convened on September 15, 2005 with a purpose of discussing allocation strategies and timeframes. The policy advisory committee membership includes approximately 75 individuals representing all relevant local, state and federal agencies, municipal and county government, private businesses and industry, the local watershed groups, and interested citizens.

5.7 Public Informational Meetings

A general public informational and public comment meeting on the Lake Helena project was conducted at the Montana Association of Counties office building in Helena on March 15, 2005. Notice of the meeting location and time were published in the Helena Independent Record on February 13, 2005, on the Montana DEQ website, and in individual letters distributed to Lake Helena Technical and Policy Advisory Committee members.

5.8 One-on-One Contacts

Lake Helena project staff have made numerous individual contacts since the project inception to gather information and advice, to inform, and to elicit cooperation. Many of these contacts and their purpose are summarized in Appendix I.

5.9 PUBLIC NOTICES

A public notice on the availability of Volume I and notice of a public informational meeting on the project was published in the Helena Independent Record on February 13, 2005.

5.10 DIRECT MAILINGS

An electronic copy of the Volume I was mailed to nearly 100 individuals included on the Lake Helena Policy and Technical Advisory Committee mailing lists, together with a cover letter providing invitations to the March 9, 2005 Technical Advisory Committee meeting and/or the March 15, 2005 public informational meeting. An electronic copy of the draft TMDL document will also be distributed to this same group via direct mail.

5.11 LIBRARY POSTINGS

Bound copies of Volume I were placed in the Lewis and Clark County Library and the Montana State Library in February 2005. Availability of the document in the libraries was noticed on the MDEQ website and in the February 13, 2005 Independent Record newspaper public notice.

6.0 REFERENCES

ATSDR. 1993. Toxicological Profile for Arsenic. U.S. Public Health Service. Agency for Toxic Substances and Disease Registry. Atlanta, GA.

Bell, M.C. 1986. *Fisheries Handbook of Engineering Requirements and Biological Criteria.* Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers, North Pacific Division, Portland, OR.

Bollman, Wease. 1998. Improving Stream Bioassessment Methods for the Mountain Valleys and Foothill Prairies Ecoregion. Unpublished Master's Thesis. University of Montana. Missoula, Montana.

Callahan, M.A. and others. 1979. Water-related fate of 129 priority pollutants, Volumes I and II. U.S. Environmental Protection Agency, Office of Water Planning and Standards, Washington, D.C., by Versar, Inc. EPA 440/4-79-029a and 029b.

Caruso, Brian S. 2004. Modeling Metals Transport and Sediment/Water Interactions in a Mining Impacted Mountain Stream. Journal of the American Water Resources Association. Volume 40, Number 6, December 2004, pages 1603-1615

Cherry, D.S.; K.L. Dickinson; J. Cairns, Jr.; and J.R. Stauffer. 1977. Preferred, avoided, and lethal temperatures of fish during rising temperature conditions. *J. Fish Res. Board Can.* 34:239–246.

Coutant, C.C. 1977. Compilation of temperature preference data. *J. Fish Res. Board Can.* 34:739–745.

Domingo, J. L. 1994. Metal-induced developmental toxicity in mammals: a review. Journal of Toxicology and Environmental Health. 42:123-141.

Eisler, R. 1985a. Cadmium hazards to fish, wildlife, and invertebrates: a synoptic review. US Fish Wildl. Ser. Biol. Rep. 85(1.2).

Eisler, R. 1987a. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service. Biological Report 85 (1.10)

Eisler, R. 1988b. Lead hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85(1.14).

Eisler, R. 1993. Zinc hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 10.

Fimreite, N. 1979. Accumulation and effects of mercury in birds. The Biogeochemistry of Mercury in the Environment. Elsevier, Holland.

Horne, M. T. and W. A. Dunson. 1995. Effects of low pH, metals, and water hardness on larval amphibians. Archives of Environmental Contamination and Toxicology. 29:500-505.

Knighton, D. 1998. *Fluvial Forms and Processes*. Oxford University Press, New York, NY.

Knopp, C. 1993. Testing Indices for Cold Water Fish Habitat. Final Report for the North Coast Regional Water Quality Control Board.

Lee, R.M., and J.N. Rinne. 1980. Critical thermal maxima of five trout species in the southwestern United States. *Trans. Amer. Fish Soc.* 109:632–635.

Magee, J.P., and T.E. McMahon. 1996. Spatial Variation in Spawning Habitat of Cutthroat Trout in a Sediment-Rich Stream Basin, In *Transactions of the American Fisheries Society* 125:768–779.

Meehan, W. R. editor. 1991. Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitats. American Fisheries Society Special Publication 19.

National Academy of Sciences. 1980. Mineral tolerances of domestic animals. National Academy of Sciences, National Research Council, Washington, D. C.

Owen, C. A. 1981. Copper deficiency and toxicity: acquired and inherited, in plants, animals, and man. Noyes Publications, New Jersey.

Prichard, D. 1998. *Riparian Area Management: A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas*. Technical Reference 1737-15. USDI-BLM, National Applied Resources Science Center, Denver, CO.

Ritter, D.F., R.C. Kochel, and J.R. Miller. 1995. Process Geomorphology. Wm. C. Brown Publishers, Dubuque, IA.

Rowe, M., D. Essig, and B. Jessup. 2003. *Guide to Selection of Sediment Targets for Use in Idaho TMDLs. Idaho Department of Environmental Quality*. Boise, ID.

Sadiq, M. 1992. Toxic metal chemistry in marine environments. Marcel Dekker. New York.

Schueler, T. 1997. Comparative pollutant removal capability of urban BMPs: A reanalysis. Watershed Protection Techniques 2(4):515–520.

Sindayigaya, E., R. V. Cauwnbergh, H. Robberecht, and H. Deelstra. 1994. Copper, zinc, manganese, iron, lead, cadmium, mercury, and arsenic in fish from Lake Tanganyika, Burundi. The Science of the Total Environment. 144:103-115

Stanley, Jr., T. R., J. W. Spann, G. J. Smith, and R. Rosscoe. 1994. Main and Interactive Effects of Arsenic and Selenium on Mallard Reproduction and Duckling Growth and Survival. Archives of Environmental Contamination and Toxicology. 26:444-51

USEPA. 1976. Effects of exposure to heavy metals on selected fresh water fish: toxicity of copper, cadmium, chromium, and lead to eggs and fry of seven fish species. Environmental Research Laboratory, Office of Research and Development, Duluth, MN. 600/3-76-105

USEPA. 1981. Health assessment document for cadmium. EPA 60/8-81023. EPA. Washington, D. C.

USEPA. 1993. Wildlife Exposure Factors Handbook. vol. I. EPA/600/R-93/187a.

USEPA. 2000. Nutrient Criteria Technical Guidance Manual – Rivers and Streams. U.S. Environmental Protection Agency Office of Water. EPA-822-B-00-002. Washington, D.C.

USEPA. 2002. Onsite Wastewater Treatment Systems Manual. EPA/625/R-00/008.

USEPA. 2005. Information on the Toxic Effects of Various Chemicals and Groups of Chemicals. Available online at http://www.epa.gov/region5/superfund/ecology/html/toxprofiles.htm.

USGS. 2003. Diurnal Variation in Trace-Metal Concentrations in Streams. U.S. Geological Survey Fact Sheet FS-086-03. Helena, Montana.

Waters, T.F. 1995. Sediment in streams- Sources, biological effects and control. American Fisheries Society Monograph 7. American Fisheries Society, Bethesda, MD.

Weaver, T.; and J. Fraley. 1991. Fisheries Habitat and Fish Populations. p. 53 – 68. In Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program. June 1991. Flathead Basin Commission, Kalispell, Montana.

Wilber, D.H. and D.G. Clarke. 2001. Biological effects of suspended sediments: a review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. North American Journal of Fisheries Management. l21:855-875.

Young, M.K., W.A. Hubert, and T.A. Wesche. 1991. Selection of measures of substrate composition to estimate survival to emergence of salmonids and to detect changes in stream substrates. *North American Journal of Fisheries Management* 11:339–346.

Yu, S., S. Barnes and V. Gerde. 1993. Testing of Best Management Practices for Controlling Highway Runoff. FHWA/VA 93-R16. Virginia Transportation Research Council, Charlottesville, VA.